

JANUARY 1952



VOL. 44 • NO. 1

# Journal

AMERICAN  
WATER WORKS  
ASSOCIATION

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Huie

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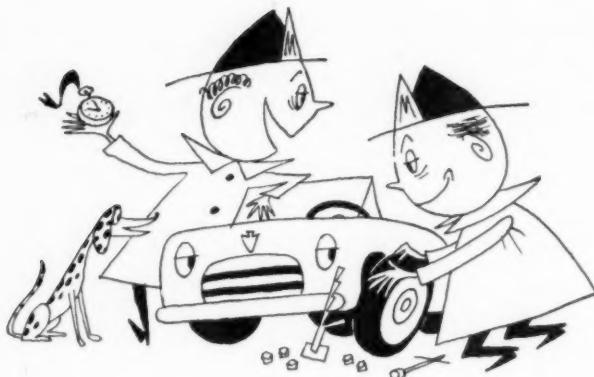
Dobbin

Clark

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# Quick as changing a wheel



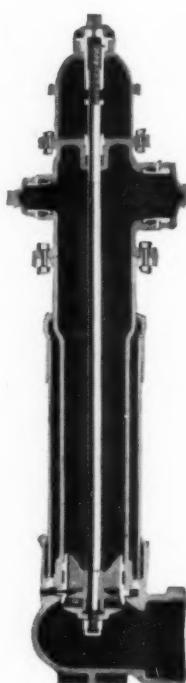
When a Mathews Hydrant is broken in a traffic accident, two men can put in a new barrel in a matter of minutes—*without excavating*. Speed of replacement is important when community safety is at stake.

## MATHEWS HYDRANTS

Made by R. D. Wood Company Public Ledger Building, Independence Square, Philadelphia 5, Pa. • Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves

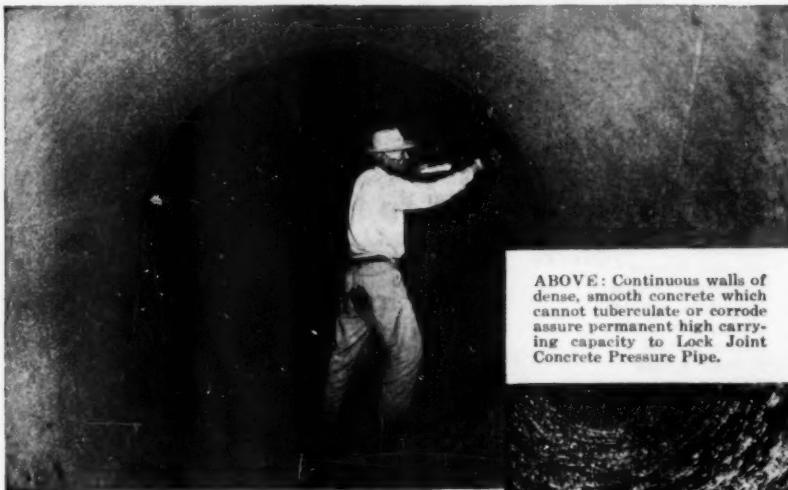
### Mathews Modernized Hydrants . . . Tops in Convenience and

**Dependability** Compression-type valve prevents flooding • Head turns 360° • Replaceable head • Nozzle sections easily changed • Nozzle sections raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for strength, toughness, elasticity • Operating thread only part to be lubricated • All working parts contained in barrel • A modern barrel makes an old Mathews good as new • Available with mechanical joint pipe connections



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*is the answer to your main problem*



Tuberculated mains—corroded mains—leaky mains—all cost municipalities, taxpayers and industry immense sums every year in added pumping costs, maintenance and repairs. Yet, by the use of Lock Joint Concrete Pressure Pipe, all of this unnecessary expense could be eliminated.

## 1. LOCK JOINT PRESSURE PIPE does not tuberculate ...

**RESULT** } **No periodic cleaning costs**  
} **No loss of income from inadequate delivery of water.**

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**RESULT** { No cost for major repairs  
No cost for periodic patchwork  
No loss of revenue while the  
line is closed for repair.

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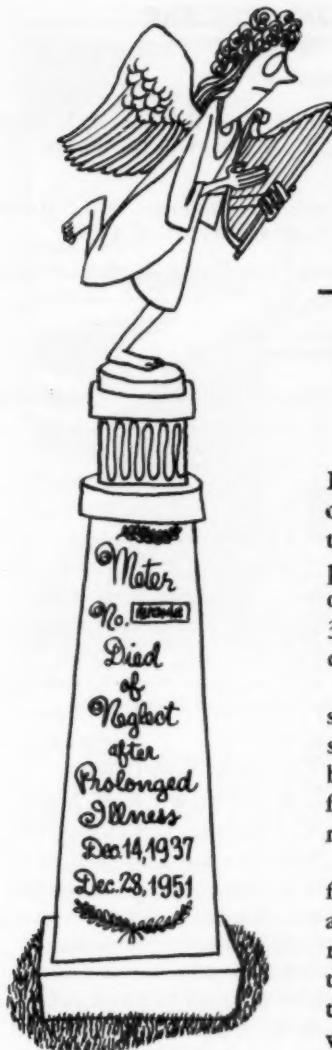
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—if you want to get  
maximum revenue  
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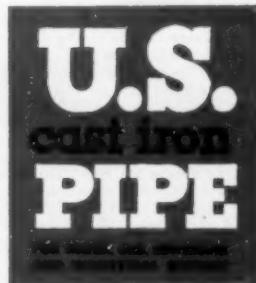
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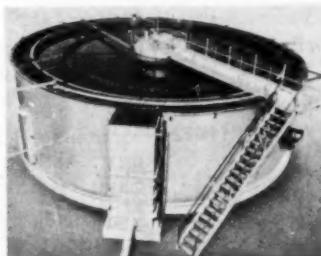
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You will find the answers to these questions in a NEW bulletin on the GRAVER REACTIVATOR . . . a high flow rate, upflow solids-contact design of water softener and clarifier.

If your water supply is hard or contains silt, clay, color, organic impurities or other suspended solids, you will find this bulletin informative and helpful. Copies will be sent to plant executives and engineers who write on their Company letterhead.

GW-454



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## COMING MEETINGS

**February**      13—New Jersey Section Winter Meeting at Essex House, Newark. Secretary: C. B. Tygert, Box 178, Newark 1, N.J.

13-15—Indiana Section at Lincoln Hotel, Indianapolis. Secretary: George G. Fassnacht, 366 Good Ave., Indianapolis 19, Ind.

**March**      20—New England Section Business Meeting at Hancock Room, Hotel Statler, Boston, Mass. Secretary: G. G. Bogren, Weston & Sampson, 14 Beacon St., Boston 8, Mass.

### AWWA ANNUAL CONFERENCE Kansas City, Mo.      May 4-9, 1952

Reservation forms have been mailed to all members, and all reservations will be cleared through the A.W.W.A. office. The hotels have agreed to accept no reservations for the 1952 Conference except as they are requested on the standard form prepared by the A.W.W.A.

**March**      24-26—Southeastern Section at Bon Air Hotel, Augusta, Ga. Secretary: T. A. Kolb, 89 Alexander St., Charleston, S.C.

26-28—Illinois Section at LaSalle Hotel, Chicago. Secretary: J. Leslie Hart, Western Sales Manager, U.S. Pipe & Foundry Co., 122 S. Michigan Ave., Chicago 3, Ill.

**April**      3-5—Arizona Section at Maricopa Inn, Mesa. Secretary: Harry S. Jordan, San. Engr., Bureau of Sanitation, State Dept. of Health, Phoenix, Ariz.

11-12—Montana Section at Northern Hotel, Billings. Secretary: Arthur W. Clarkson, Assistant Director, Div. of Sanitary Engineering, State Board of Health, Helena, Mont.

16-18—New York Section at Hotel Syracuse, Syracuse. Secretary: R. K. Blanchard, 50 W. 50 St., New York 20, N.Y.

17-18—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary: E. Bruce Meier, Asst. Prof., Univ. of Nebraska, Lincoln.

**May**      6—Kansas Section Business Meeting Luncheon, at Hotel President, Kansas City, Mo. Secretary, H. W. Badley, 640 Highland St., Salina, Kan.

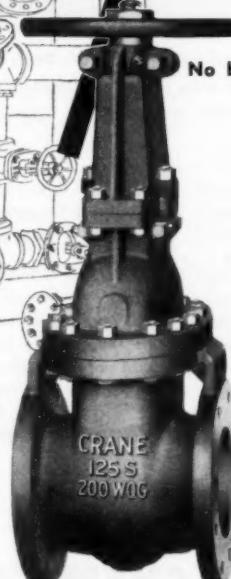
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piping repairs

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Crane No. 465½  
Iron Body Gate Valve



You make fewer of them  
by using Dependable Quality

## CRANE VALVES

*...That's why  
more Crane Valves  
are used  
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No bonnet joint trouble with this valve

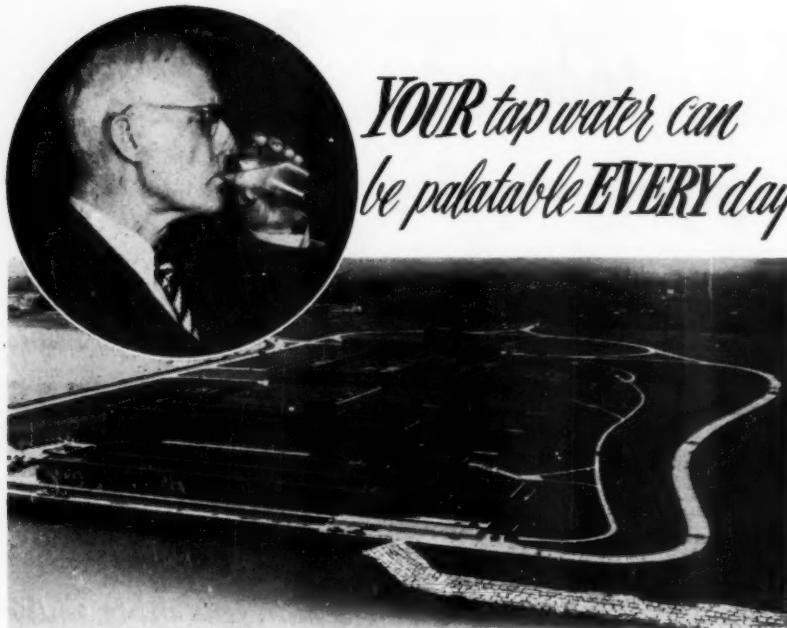
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be palatable **EVERY** day*

*John R. Baylis, world renowned water chemist, says that, "Activated Carbon will remove every taste and odor producing pollution occurring in American surface water supplies if applied properly in sufficient dosages."*

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*NOTE: This advertisement is published with the idea of promoting production of uniformly palatable water, and the quotations from outstanding water works authorities should not be construed as being an endorsement for any particular product.*

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# Journal

AMERICAN WATER WORKS ASSOCIATION

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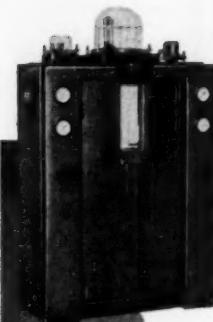
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# Journal

AMERICAN WATER WORKS ASSOCIATION

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## National Research Council Viewpoint on Fluoridation

### Ad Hoc Committee Report

*Report of the Ad Hoc Committee on Fluoridation of Water Supplies,  
Div. of Medical Sciences, National Research Council, Washington,  
D.C.*

THE Ad Hoc Committee on Fluoridation of Water Supplies was convened and directed to express its judgment whether, on a basis of a review of the present status of scientific knowledge, supplementing the fluoride content of public water supplies for the partial prevention of dental caries is a desirable and safe procedure from a physiological viewpoint. Specifically, it has been advocated that, if necessary because of the deficiency of this element, the fluoride content of the public water supplies be adjusted to insure a mean content of approximately 1 ppm of fluorine. While some aspects of water fluoridation are still in the experimental stage, its application has been shown to be technologically practical and economically feasible. However, it remains to be determined by each municipality contemplating installation of this procedure: [1] what benefits may be expected, and [2] what

the potential liabilities are. After reviewing the available evidence, the committee concluded that the following are the principal considerations, briefly stated, upon which judgment must be based:

1. Under normal conditions of living, fluorine is a trace element in human nutrition (1). Minute amounts are absorbed from certain foods and drinking water and, to a limited extent, are retained by dental and osseous tissues. The quantity of fluorine ingested in food is a relatively unimportant variable; the average diet contains 0.2-0.3 mg daily. Of greater importance is the variable quantity ingested in drinking water. Many of the public water supplies in the United States, particularly those of the large cities, which are derived from rivers, lakes, and ponds, are practically fluoride-free; others contain from traces to 1.5 ppm fluorine as fluorides. A

number of supplies, particularly those obtained from deep wells and aquifers irregularly distributed in various parts of the country, contain from 1.5 ppm to 7 or 8 ppm—very rarely more (2).

2. From the epidemiological investigations of Dean (3), there is convincing evidence that, within certain limits, there is an inverse relationship between the natural fluoride content of drinking water and the frequency of dental caries in children who depend upon these supplies. The most useful index of the amount of caries is the number of decayed, missing, and filled permanent teeth (DMF) per child, per 100 children, or per 100 permanent teeth, at specified ages.

Dean's original observations were based upon 7,257 selected white school children aged 12-14 in 21 cities of four states. The prevalence of caries (DMF) was greatest in those children who had used continuously from birth the public water supplies which were fluoride-free. The prevalence was progressively less in comparable children reared in cities with public water supplies having a fluoride content up to approximately 1 ppm. Beyond this concentration there was little, if any, advantage. Children reared in cities where drinking water contained approximately 1 ppm of fluoride experienced only approximately one-third as much dental caries as those reared in cities where water supplies were fluoride-free (4). These basic observations have been confirmed and extended by investigators in this and other countries.

3. The caries-preventive effect of adequate fluoride intake is principally conferred upon children when the dentine and enamel of the permanent dentition are being formed: that is, from birth to approximately the twelfth

year. There is evidence that this increased resistance to dental caries is carried over to some extent into later life, so that there is a delay of at least several years in the incidence of caries (5). A recent detailed epidemiological study of adult populations considerably extends knowledge in this field (6). These observations show that marked caries-inhibitory effects of fluoride waters are operative in the 35-39- and 40-44-yr-old groups.

4. A considerable number of experimental studies have been conducted in the laboratory to explore the inhibition by fluorides of induced experimental caries in rats and hamsters, and to explain this action. The results give consistent support to the concept of a relationship between human caries and fluorides (1). Although it appears probable that caries resistance is associated with the incorporation of fluorides into the tooth structure, the exact mechanism by which it is mediated is unknown. The causes of caries are only partially understood.

5. The margin between the optimal quantity of fluoride in drinking water that is required for maximal benefit in tooth development and the amount that produces undesirable physiological effects is sufficiently wide to be of no concern. The most sensitive indication of the latter amount is the enamel defect of the permanent teeth known as endemic fluorosis, or mottled enamel. The epidemiological studies of Dean (7), which were based upon examination of 5,824 white children in ten states, showed a direct correlation between severity of the manifestations of mottled enamel and the increasing fluoride content (up to 5 ppm) of the water supplies upon which the children were dependent. At approximately 1 ppm, less than 10 per cent of chil-

dren show the least detectable evidence of disturbances in enamel formation, which are not visible except to the trained eye of the examining dentist. Beginning at approximately 2 ppm, an increasing proportion of children have mottled enamel of a grade that is easily apparent. Although such teeth are caries-resistant, they are esthetically objectionable.

6. Although the safe level of fluoride concentration to afford a maximum caries-preventive effect without mottled enamel is approximately 1 ppm, this level varies somewhat with climatic and other factors and must be ascertained for each general area (8). For practical public health purposes, it has been proposed that a safe level has been reached when not more than 10-15 per cent of children aged 12-14 who have used water supplies since birth, and who have been examined under standard conditions, show the mildest detectable type of mottled enamel. Under the climatological conditions prevailing in the Chicago area, where the mean annual temperature is approximately 49°F, this upper limit has been reached by domestic water supplies containing approximately 1.0-1.5 ppm fluoride. On the other hand, in the vicinity of Moultrie or Brunswick, Ga., with a mean annual temperature of 68°F, the upper level has been found to be associated with water supplies containing only 0.5-0.7 ppm.

7. There is an extensive literature on the pharmacology and toxicology of fluorine and its compounds. This field has been reviewed by several authors (9-12). Only those parts of it which deal with the cumulative action of fluorides are pertinent to the question of the safety of fluoridation. Chronic fluoride intoxication characterized by

bone, joint, and other tissue changes has been the cause of impaired skeletal function in Danish workmen exposed to fluoride dusts as an occupational hazard (13). The presence of concentrations of fluorides in excess of 5 ppm in water supplies in certain parts of the world has been reported to have given rise to a number of cases of chronic fluorosis, but the reported data are inadequate to establish the threshold concentration at which storage may be expected to occur to a potentially harmful extent. A radiologic survey at Bartlett, Tex.,\* where the water contains 8 ppm, revealed an increased bone density not associated with functional impairment in 11 per cent of those examined, but roentgenologic examinations of a limited number of persons living in areas where the water contained from 1.2-3.0 ppm, revealed no evidence of fluorosis (14).

The fluoride concentrations in the urine of normal teen-age boys and young men closely approximate those in their drinking water in regions where the water supplies contain from 0.2-4.7 ppm (9). Fluorine-balance studies furnish additional evidence that the human body eliminates the major portion of food- and water-borne fluoride when the quantities ingested do not exceed 4.0-5.0 mg of fluoride daily (1), although the daily ingestion of 6.0 mg led to demonstrable storage (15).

In the accumulated experience, there is no evidence that the prolonged ingestion of drinking water with a mean concentration of fluorides below the level causing mottled enamel would

\* Testimony given during the hearing on the tolerance for fluoride spray residue on apples and pears, held pursuant to the notice issued by the Federal Security Admin., May 1, 1944 (9F.R. 4654).

have adverse physiological effects. As the water supplies in various parts of the country contain considerably greater amounts, it is desirable that epidemiologic surveys of the incidence of chronic fluorosis be made in those regions, and that further balance studies be undertaken in order to establish the facts about storage of fluoride at moderately elevated levels of intake.

8. In 1945 studies were begun to ascertain whether the adjustment of the fluoride content of a public water supply to the optimal level with commercially available fluorides would confer the same caries-inhibitory effects as do waters which carry the same concentrations of fluoride naturally.

Preliminary analysis of the first four years is now available on two studies in which the observations were carefully controlled: [1] the Grand Rapids-Muskegon-Aurora study (16), and [2] the Newburgh-Kingston study (17, 18).

Beginning in January 1945, sodium fluoride was added to the Grand Rapids, Mich., water supply in sufficient quantities to insure continuous maintenance of a level of approximately 1 ppm. In order to establish a base line of dental caries experience prior to fluoridation, 19,680 children with history of continuous residence in Grand Rapids were given a complete dental examination. In addition, 4,291 children were examined in Muskegon, Mich., a city which derives its fluoride-free water supply from the same sources as does Grand Rapids—from Lake Michigan. An additional 5,116 children were examined in Aurora, Ill., where the community water has for years contained 1.2 ppm of natural fluoride. Data from examinations

conducted at Grand Rapids and Muskegon during the autumn of each year since 1945 (that is, five yearly examinations since fluoridation was begun) have been tabulated. These examinations were made on representative children from the kindergarten, first, fourth, eighth, and eleventh school grades. In Grand Rapids, there has been a reduction in caries experience in the permanent teeth of children examined in 1949, particularly in the younger age groups, from the rate expected on the basis of the 1944-45 examinations. The apparent amount of reduction in the DMF rate per child at ages 6, 9, 13, and 15 yr, was approximately 51, 36, 17, and 12 per cent, respectively. Concurrently, there has been a slight decline in the caries rates reported by Muskegon with its fluoride-free water supply but it is relatively small and inconsistent: 22 per cent in the 6-yr-olds and 28 per cent in the 7-yr-olds. This factor is unexplained. In the 5-, 6- and 7-year-old groups at Grand Rapids, the DMF rates now approximate those of comparable groups of children in Aurora. Preliminary analyses of the 1950 dental examinations at Muskegon and Grand Rapids indicate that the observed dental caries experience at Muskegon is again similar to that recorded in the 1944-45 base line. At Grand Rapids, a further reduction in dental caries prevalence was observed.

In another study, beginning in May 1945, sodium fluoride was added to the water supply of Newburgh, N.Y., to provide a content of 1.2 ppm, whereas the Kingston, N.Y., supply was and has continued to be fluoride-free. At the end of four years of fluoride treatment of Newburgh's water supply, analysis was made of the data on den-

tal caries experience both of deciduous and permanent teeth of approximately 3,200 school children 5-12 yr old in Newburgh, and 3,100 children of the same age in Kingston. In brief, the investigators conclude that the DMF rates among permanent teeth of the 6-12-yr-old children in Newburgh show a consistent downward trend after four years of fluoridation, whereas the DMF rates in the control city of Kingston show no changes. The reduction in Newburgh is from 20.6 DMF per 100 permanent teeth to 13.9, or a reduction of 32.5 per cent. The rate in Kingston remained at 20.2 DMF per 100 permanent teeth. Because the first permanent molars are the teeth most affected by dental caries, a special analysis of the condition of these teeth was made. The number of caries-free first permanent molars increased in Newburgh, after four years of fluoride exposure among 6-9-yr-old children, from 59 per 100 molars to 77. The number of caries-free permanent teeth among Kingston children of the same age remained essentially unchanged.

From these two studies, therefore, it appears that the adjustment of the fluoride concentration to optimal amounts in a water supply previously deficient in this element has resulted in considerable reduction of caries in children. Just how great a reduction may be ultimately effected will have to be determined after a longer period of observation. Reports from other cities which have installed this procedure tend to corroborate the studies mentioned (19-23). Continued observations, however, are essential for the establishment of the degree of effectiveness for higher age groups.

9. In the control studies to which reference was made in the preceding paragraph, sodium fluoride (NaF) was added to the water supplies. If the availability of fluoride ion is the same, the use of sodium silicofluoride (fluosilicate,  $\text{Na}_2\text{SiF}_6$ ) should result in considerable savings. Experimental studies indicate that the fluorine in sodium fluoride and sodium fluosilicate produce similar physiological effects upon rats (24), and are equally effective in inhibiting the development of induced dental caries in rats (25). Accordingly, it is inferred that this principle would apply to human experience as well, although it has not yet been demonstrated. Other considerations being equal, for reasons of economy the cheaper material (fluosilicate) is recommended. For smaller public water supplies, however, other factors such as the amount of available space, handling hazards, and equipment preference will determine the choice of the compound used.

10. The statement that fluoridation of water supplies reduces tooth decay by 65 per cent is postulated on an expectancy for a population using a fluoride-free water supply. When a public water supply naturally containing 0.4-0.5 ppm, of fluoride is adjusted to the optimal level (1.0 ppm), the reduction in dental caries prevalence obviously would be less. Upon the basis of information at present available, it is not possible to predict how much reduction of caries will be apparent in the adult population. Other factors—genetic, dietary, bacteriologic, the availability of dental services, and so on—affect the prevalence of caries and vary in every community. Fluoridation is a partial caries-control procedure and does not

eliminate the need for other dental health measures.

11. The promotion, initiation, supervision, and proper operation of the fluoridation of public water supplies is a responsibility of the state department of health, acting jointly through its bureau or division of dental health and through the division of public health engineering, with the collaboration of the dental and medical professions. Suitable local plans for dental health surveys before fluoridation and periodic evaluations should be set up by the dental public health program director. These surveys should provide data suitable for calculating an index of caries attack and an index of the frequency and severity of dental fluorosis. Engineering aspects of fluoridation, such as tests to determine the fluoride content of the water, safety provisions, and training of operators, should be covered by state regulations. The statement of policy and procedure formulated by the American Water Works Association will be acceptable to most state departments of health (26). Municipalities contemplating the installation of fluoridation should look to the state health department for expert guidance. Many small communities would be unable to maintain satisfactory fluoridation practice without assistance. There are many so-called automatic plants applying chlorination, which allegedly do not require full-time attendance of a water works operator. Many have very limited laboratory facilities or lack technical personnel to make accurate chemical determinations of fluoride content. Ultimately, state or regional laboratories will have to take over routine chemical examination of samples along with established bac-

teriological control. Provision for periodic visits by a state sanitary engineer cannot be considered adequate supervision.

### **Summary and Conclusions**

Under normal conditions of living, fluorine is a trace element in human nutrition. A variable and important source of it is drinking water. Many of the public water supplies in the United States are deficient in this element. Children who depend upon such supplies have a high dental-caries-attack rate compared with children living in cities having water supplies containing approximately 1 ppm of fluoride. The advantage of the latter group is considerable and amounts to one-third to one-half as much caries. The caries-preventive effect of adequate fluoride intake is principally conferred upon children until approximately the twelfth year of life—the period during which dentine and enamel of the permanent dentition are being formed. This increased resistance to dental caries is carried over into later life to an appreciable degree.

The results of experimental studies conducted in the laboratory give consistent support to the concept of the inhibitory effect of fluoride on the caries process. There is a safe margin between trace quantities in drinking water which are required for optimal dental health and that amount which produces undesirable physiological effects. The most sensitive indication of the latter amount is interference with normal calcification of the teeth which is manifested in mottled enamel, or endemic fluorosis. This effect, although compatible with caries-resistant tooth structure and, within certain limits, with apparent physiological well

being, is esthetically undesirable. The level of fluoride concentration in drinking water that is associated with the appearance of mottled enamel varies with individual susceptibility and with the amount of water consumed. The upper level of safety has been reached, in the northern part of the United States, in domestic water supplies containing approximately 1.0-1.5 ppm fluorine and, in the southern part of the country, with supplies containing approximately 0.7 ppm.

There is no reason to believe that prolonged ingestion of drinking water with a mean concentration below the level causing mottled enamel will have an adverse physiological effect. Progress reports in several communities in which sodium fluoride has been added to the water supplies of low fluoride content indicate that this procedure will reduce the caries-attack rate in children. There is evidence to suggest that it will confer an appreciable measure of protection to their teeth after they have become adults.

In view of these considerations, this committee recommends that any community that has a child population of sufficient size and obtains its water supply from sources which are free from or are extremely low in fluorides should consider the practicability and economic feasibility of adjusting the concentration to optimal levels. This adjustment should be in accordance with climatic factors, and a constant chemical control should be maintained. With proper safeguards, this procedure appears to be harmless. However, it should be conducted under expert dental and engineering supervision by the state board of health. It should not be undertaken unless this supervision can be provided.

The degree of reduction in the prevalence of caries that will actually be realized in a particular community will vary according to local conditions. The procedure will supplement but not supplant other dental health measures. Approximately one-half of the population of this country is living in small villages and rural areas and will not benefit by fluoridation of public water supplies.\* Other provisions for preventing dental caries in this fraction of the population should be continued and developed.

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\* To prevent misinterpretation of this statement, it may be necessary to point out that, upon the basis of the 1950 census, about one-third of the nation's population does not have public water supply service. It was the opinion of the committee, when writing the report, that in some communities where a public water supply exists, the child population might be so small and the ability to provide competent control of fluoridation so unlikely, that for the present at least, it should be assumed that one-half of the population is beyond the reach of communal fluoridation of the water supply.—ED.

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### Statement by American Medical Association

*The Council on Pharmacy and Chemistry and the Council on Foods and Nutrition of the American Medical Assn., on Nov. 12, 1951, issued this joint statement on the fluoridation of public water supplies.*

THE Council on Pharmacy and Chemistry and the Council on Foods and Nutrition of the American Medical Assn. have been requested to state their opinion regarding the safety of fluoridation of water supplies, a procedure which now has been adopted by more than 140 cities.

The councils are unaware of any evidence that fluoridation of community water supplies up to a concentration of 1 ppm would lead to structural changes in the bones or to an increase in the incidence of fractures. The only difficulty so far revealed is a possible increase in mottling of the tooth enamel. From the available evidence based on thousands of observations, the incidence of mottling of the enamel in children who drink water containing fluoride up to a concentration of 1 ppm is minimal and detectable only by careful dental examination. It occurs only in a

small percentage of children and is so slight as not to present a problem from the point of view of appearance or strength of the teeth. Evidence of toxicity other than the effect on enamel has not been reported in communities where the water supply has several times this concentration. After considering the evidence available at this time, the councils believe that the use of drinking water containing up to 1 ppm is safe. However, the use of products which are naturally high in fluoride content, such as bone meal tablets, or of lozenges, dentifrices, or chewing gum, to which fluoride has been added, should be avoided where the drinking water has been fluoridated. In places where children are subjected to warm temperatures and consequently drink large amounts of water, a lower concentration of fluoride may be necessary to avoid mottling.

## **Municipal Liability in Damage Suits From Fluoridation**

**By Burnell Waldrep**

*A paper presented on Oct. 17, 1951, at the Southwest Section Meeting, Fort Worth, Tex., by Burnell Waldrep, Asst. Attorney Gen., State of Texas, Austin, Tex. The conclusions stated are those of the author and not of the office of Attorney General.*

THE fluoridation of water is a relatively new process and, as it impinges on the fundamental principles of law governing liability of municipal corporations, presents many complex problems. Whether or not fluoridation will actually cause damage may be referred to the experts who have made a study of the process; this discussion is based upon a hypothetical situation in which damage might result.

It is uniformly recognized that a municipal corporation has two functions. The first of these functions is the private or proprietary function, and the second one of them is the governmental function in which the corporation acts as the arm or agent of the state. The intermingling of these two functions has resulted in difficulty in determining the boundary that separates them. The doctrine that exempts a municipal corporation from liability for torts resulting from the performance of its governmental functions is based on the principle that the undertaking is taken not to promote the private interests of the municipality as a corporate entity, but rather to benefit the public. In performing this function, the corporation is acting in its capacity of a public agent of either the state or the local municipality.

### **Legal Basis**

In determining the liability of municipal corporations for torts resulting in personal injuries or deaths, courts of almost all jurisdictions base their decisions on the evidence which proves whether the activity out of which the injury or death arose was governmental or public, or whether it was proprietary, private, or corporate. According to this general rule of immunity, if the function is a public or governmental one, the municipality is not responsible for the negligence of its officers or employees.

It is sometimes difficult to distinguish between the two capacities of a municipality. The express functions are very closely related, and that which has been defined as a municipal function in some states has been defined as a proprietary function in others. The courts in general, however, and particularly those in Texas, are committed to the rule that a municipality engaged in maintaining and operating water works does so in the exercise of a proprietary or private function.

### **Liability Under Private Function**

It is agreed that a municipal corporation engaged in a private, corporate,

or proprietary function, as distinguished from purely public and governmental activity, is answerable for its agent's negligence.\* Great differences of opinion exist, however, in interpreting which functions are governmental, or public, and which ones are private, or corporate. Functions defined as governmental in some jurisdictions are defined as corporate in others.

McQuillin states (1, p. 141):

The questions generally involved at the present time are whether the duty is a governmental or a corporate one, and whether the officer or agent is really a servant of the municipality. No recovery can be had, as a general rule, in the following cases:

1. Where the power or duty involved is a governmental as distinguished from a corporate power or duty.

2. Where the board or person whose alleged wrongful act is the basis of the cause of action: [a] is not the servant of the municipality, or [b] the act was beyond the scope of authority of such board or person and has not been ratified, or [c] the act, or the work in which the board or person was engaged, was not only beyond the scope of the authority of such person or board but was also beyond the power of the municipality itself, i.e., *ultra vires* in the strict sense of the term.†

\* *Amarillo v. Ware*, 120 Tex. 456, 40 S.W. 2d 57 (1931); *Dilley v. City of Houston*, 148 Tex. 191, 222 S.W. 2d 992 (1949); *Little Rock v. Holland*, 184 Ark. 381, 42 S.W. 2d 383; *Barker v. City of Santa Fe*, 47 N.M. 85, 136 P. 2d 480 (1943); *City of Sand Springs v. Gray*, 182 Okla. 248, 77 P. 2d 56 (1938); *Oklahoma City v. Hill*, 6 Okla. 114, 50 Pac. 242 (1897) (1, p. 185).

† 7 Tex. Jur. Supp. 461, Municipal Corporations, Sec. 289a, states: "It is a matter of no little difficulty to define what are and what are not purely governmental duties of a city. To a very large extent these

## Determination of Function

As the city's liability depends upon a determination of whether it is engaged in a proprietary or governmental function, it is necessary to ascertain into which of these categories the operation of a water works system should be placed.

In *City of Crosbyton v. Texas-New Mexico Utilities Co.*, 157 S.W. 2d 418, 420 (Tex. Civ. App. 1941), the court said:

In the exercise of its proprietary or business functions, however, such as those which it exercises when it enters into a contract for the private interests of its own inhabitants or of itself, a municipal corporation is limited by no such restriction. It is at liberty to exercise these powers in the same way and to the same extent as individuals or private corporations and it is settled by a long line of decisions of the courts of this state that the ownership and operation of public utilities, such as water works, electric light plants and street railways is not a governmental function but is proprietary in its nature and constitutes a business or corporate function of the city.

In *City of Wichita Falls v. Lipscomb*, 50 S.W. 2d 867 (Tex. Civ. App. 1932, error ref.), the court said:

questions can only be settled by the facts of each particular case, so variant are the conditions under which this question arises." Although various tests have been urged by different courts in determining whether or not a function performed by a municipality is governmental or corporate, the underlying test is said to be "whether the act performed by a city is public in its nature and performed as the agent of the State in the furtherance of general law for the interest of the public at large, or whether it is performed primarily for the benefit of those within the corporate limits of the municipality."

We have reached the conclusion that the construction and maintenance of the water works system in the city of Wichita Falls was not the exercise of a governmental function, but was in pursuance of a corporate enterprise, and that the alleged negligence of the city urged by the plaintiff, and the injury to her as the proximate result thereof, showed a common-law right of action for the damages she sought.\*

If the courts determine that the fluoridation of water constituted a governmental function in the interest of public health, of course, no liability would attach.

In *City of Dallas v. Smith*, 130 Tex. 225, 107 S.W. 2d 872 (1937), the court said:

Because of the very nature of the power to make provision for the public health and its importance to all the people of the state, and because in exercising such power the cities are required to administer and enforce and do administer and enforce the general laws and the general policy of the state, such power in our opinion falls within that class described by Judge Stayton in *City of Galveston v. Posnainsky*, 62 Tex. 118, 127, 50 Am. Rep. 517, as follows:

"It would seem that, insofar as municipal corporations of any class, and however incorporated, exercise powers conferred on them for purposes essentially public—purposes pertaining to the administration of general laws made to enforce the general policy of the state—they should be deemed agencies of the state, and not subject to be sued for any act or omission occurring while in the exercise of such power, unless, by statute, the action be given; that, in reference to such matters, they should stand as does sover-

eighty, whose agents they are, subject to be sued only when the state, by statute, declared they may be."

The conclusions above expressed are supported by the great weight of authority, including the decisions of the courts of this state. Dillon's statement of the general rule is: "The power or even duty on the part of a municipal corporation to make provision for the public health and for the care of the sick and destitute, appertains to it in its governmental or public, and not in its corporate, or as it is sometimes called, private capacity."

Because, in the above decisions, the operation of a water works system of a municipality is defined as a proprietary function, it becomes evident that any liability resulting from the fluoridation of water must be occasioned by negligence of the agents administering the system. In other words, before recovery would be authorized, evidence would be required to prove that damage was the result of negligence. Any particular liability from the fluoridation process, therefore, would require individual determination from the particular evidence offered.

#### Lack of Precedent

As no decision has been rendered on liability in the use of the fluoridation process, it may be of value to examine those decisions bearing on the application of the rules in question under analogous or similar conditions—particularly those decisions in damage suits occasioned by epidemics of typhoid fever.

*Stoker v. Ogden City*, 54 P. 2d 849 (Utah Sup. 1936), was an action for damages against the city for the death of a resident from typhoid fever. The disease was alleged to have been caused by the drinking of impure city water.

\* *Butterworth v. City of Henrietta*, 61 S.W. 975 (Tex. Civ. App. 1901, error ref.); *Greenville Water Co. v. Beckham*, 118 S.W. 889 (Tex. Civ. App. 1909, error ref.).

In late June and early July 1929, seventeen suspected cases of typhoid fever appeared in Ogden City. The defendant introduced evidence to show that the water supply was not contaminated and that five of the persons who contracted the disease had eaten at a certain candy kitchen and others had eaten at a particular smokery. Many medical experts were called and examined and some expert witnesses testified that it was very probable that the water supply was the source of the typhoid infection and, further, that the water supply, in their opinion, caused the illness. To prevail, the plaintiffs had to prove that:

1. The sickness from which the deceased died was contracted from the use of the water furnished by the defendant city.
2. The defendant city was guilty of negligence in supplying such contaminated water.

The jury found for the defendant and the judgment was in favor of the city. This judgment of the trial court was later affirmed by the appellate court.\*

### Applying Law to Fluoridation

As the hypothetical situation under discussion is one of first impression, establishing a hard and fast rule on the liability of a city by reason of fluoridation would be most difficult. Because liability depends upon the character of the function performed, and

\* Also see *Martin v. Springfield City Water Co.*, 128 S.W. 2d 674 (Mo. Ct. App. 1939), in which the court said: "The liability of a city water company for injuries resulting from typhoid fever allegedly developing as a result of the drinking of contaminated water furnished by the company was for the jury."

because water works operation is generally performed in a proprietary capacity, the question is resolved on the basis of negligence. The burden, therefore, is on the plaintiff to establish by a preponderance of evidence that the agents of the city were performing a proprietary function, and that they were doing so in a negligent manner that resulted in injury to the plaintiff.

A causal connection must exist between the damage suffered by the plaintiff and the actual placing of the fluoride in the water. In other words, proximate cause of such injuries must be attributed to the negligence, if any, of the city's agents during the fluoridation process. These issues obviously must be decided by a jury. If a jury finds sufficient facts upon which to base liability, the governing rule for appeal is on the adequacy of that evidence. This burden, which is on the plaintiff, would therefore seem insurmountable because of all the attending circumstances and the factual aspects of fluoridation.

### Hypothetical Case

To illustrate the application of the rules mentioned, it is assumed that a specific city fails to supply an adequate amount of fluoride in the water supply, thereby allegedly allowing the plaintiff's teeth to become damaged. In this situation, the city clearly would not be liable because of nonfeasance.† If, however, the employees of this city, negligently administer the amount of fluoride placed in the city's water supply and thereby cause damage to the plaintiff's health, the city would be liable if it is found that such negligence

† *Moch Co. v. Rensselaer Water Co.*, 247 N.Y. 160, 159 N.E. 896, 62 A.L.R. 1199.

actually was the proximate cause of the damage. This hypothetical example is a typical negligence case, and one which is predicated upon issues of fact. As previously stated, of course, liability would also depend on whether the operation of the water plant was a proprietary function.

### Conclusions

The liability of a city for the use of fluoride in the city water has not been specifically adjudicated. Although, in the law, the operation of a water system by a municipality is a proprietary function, a damage which was

proximately occasioned by negligence must be established. To recover, an individual would have to show that he suffered an injury because of the negligent use of fluoride. All of these questions are within the province of a jury with proper instructions from the court.

It is sufficient to conclude that any attempt to prove liability upon the part of the city because of the fluoridation process would, in the author's opinion, be a somewhat difficult task.

### Reference

1. SMITH, RAY, ET AL. *On Municipal Corporations*. Callaghan Co., Chicago, Ill. (3rd ed. 1950), vol. 18, sec. 53.



## Safety in Water Departments

By Lynn Erratt

*A paper presented on Sept. 21, 1951, at the Michigan Section Meeting, St. Joseph, Mich., by Lynn Erratt, Safety Adviser, Board of Water and Electric Light Comrs., Lansing, Mich.*

**M**ORE than anyone else, those who are responsible for the production and delivery of pure water for the public, control the health of the community they serve. The health and safety of these workers should be a prime consideration in the operation of water departments. Accident records show, however, that their welfare is not given such consideration. Water works employees seem to have more than their share of accidents, too many of which are serious, resulting in death, permanent disability, and suffering—in addition to considerable monetary losses to the operating agencies.

It is recognized that more than 90 per cent of all accidents are preventable, and that the means of reducing accident rates are at hand in the application of better engineering to new or existing facilities, the education of individuals concerned with operation, and the enforcement of reasonable and just safety rules.

Each water department should be divided into three functional categories to facilitate proper consideration of safety problems that may arise.

1. *Production.* The production division includes wells of all types, pumping facilities, pumping stations, water reservoirs, and similar facilities.

2. *Treatment.* The treatment category includes various types of condi-

tioning plants, storage facilities, and chemical treatment and testing installations.

3. *Distribution.* Distribution includes all piping from the pumping station to the consumer. Such operations as construction and maintenance of mains and domestic or commercial services, metering, meter reading, and maintenance of fire hydrants are involved.

### Results of Safe Operation

Safe operation in any organization will result in more efficiency and, consequently, in monetary savings. This fact has been proved in all industries. The safe way is the best way. To profit from the experiences of the past, which have too often been costly and painful, some of the routine occurrences in the three functional categories mentioned above, should be discussed.

It is attested by all statistics that the safest factor is a safe worker. As in any industry, approximately 85 per cent of all injuries in water works operation are caused by personnel failure. The installation of every known mechanical safeguard would eliminate only 15 per cent of injuries. This factor indicates that workers should be carefully selected and even more carefully educated for the jobs they are to perform. The most valuable and important equip-

ment in any operation is the employee. He should be chosen, trained, and cared for at least as carefully as is an expensive pump or motor.

### **Production Hazards and Safety Aids**

Modern pumps and motors are well designed by manufacturers for safe operation, but many plants have older equipment which may require guarding. Belts should be screened, rotating parts covered, and hot areas protected. Almost all water production equipment is heavy and bulky. Adequate help, both mechanical and physical, will prevent many back injuries caused by strain. Most surfaces are wet and slippery. Ample protection is needed, therefore, to insure good footing, and extra care should be taken in job planning before any work is attempted.

At steam stations, maintenance and repair work exposes the operator to hot piping and steam leaks which could cause burns. Poorly repaired extension cords can easily become grounded in wet areas and cause electrocution. Low-voltage cords are desirable for inside boiler or tank work.

Heavy wrenches and tongs that are used for large diameter pipe must be in perfect condition. Hand tools demand frequent inspection. A loose-fitting end wrench can cause a bad fall from a scaffold or boiler landing. Handling well pipe covered with scale calls for eye protection during cleaning operations.

### **Treatment Hazards and Aids**

Water treatment plants have most of the mechanical hazards mentioned above plus other hazards from such chemicals as lime, soda ash, phosphate, alum, and chlorine. The chemical suppliers provide excellent bulletins on

safe handling of all of these materials. Their recommendations should be rigorously followed.

Chlorine handlers must have available proper protective masks and be trained to perform rescue work in gassed areas. Proper training in handling leaking chlorine cylinders is also essential.

Water-testing procedures demand properly trained and supervised personnel to insure dependably accurate results.

### **Distribution Hazard and Aids**

Water distribution crews work outdoors at almost all times. This situation presents hazards with which other water department personnel are not faced.

Excavations for mains, services, or manholes may require shoring of various types if the holes are deep or the ground texture is weak. Tools and materials should be removed from the edge of the ditch to prevent their falling on workmen below. Barriers should be arranged to protect the workmen from traffic, and motorists from the excavation. Warning lights are necessary if the hole is to be open overnight, barriers should be properly painted so they can be seen even in poor light, and lantern fuel should be properly handled to prevent fires.

The use of pavement breakers requires the wearing of goggles not only by the operator, but by nearby workmen who might be hit by flying concrete.

Hoists or cranes are required in handling heavy pipe. These machines must have good cables that are in safe operating condition, and the machinery should be guarded. Some of this equipment requires special operating knowl-

edge and should be run only by fully trained workers. No one should ever be allowed to work under a crane load.

Large valves are occasionally located in manholes or vaults. These valves should be checked for the presence of gas or for oxygen deficiency before the areas are entered.

### General Recommendations

Some of the general activities that are high on the list of recommendations are:

1. Provide first-aid training to employees, and, in these programs, emphasize the teaching of artificial respiration techniques.
2. Provide prescription-ground safety glasses for workmen who wear glasses.

3. Encourage the wearing of safety shoes. Many disabling foot injuries are prevented by this precaution.

4. Promote off-the-job safety practices. Approximately 60 per cent of disabling injuries occur at home or in traffic, and the employee is lost from his work as a result of such an accident just as much as if he were injured on the job. Many fine films on this subject are available (1).

5. Workers should be indoctrinated with such slogans as, "You are your brother's keeper." If carried in mind, such slogans can easily mean that "the life he saves may be his own."

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## New York City's Interest in the Delaware River

By Irving V. A. Huie

*A paper presented on Sept. 13, 1951, at the New York Section Meeting, Whiteface, N.Y., by Irving V. A. Huie, President, Board of Water Supply, New York, N.Y.*

THE Board of Water Supply of New York City has endorsed the Incode\* project, but this endorsement is predicated wholly upon the assurance that both stages of the project will be built and will be made available. The factors upon which the Board's position is based are depicted graphically in Fig. 1.

Over the years, the Board has made a number of studies to support its predictions of future water needs. The city's Department of Water Supply, Gas and Electricity, which operates the water system, has made similar studies. Inasmuch as these surveys have had to be based on estimates of population trends, increased per capita usage, and increased demands by industry, it is not surprising that no two of them have given the same result. Analysis of the various data has, however, provided the Board a sound basis for drawing its conclusions. And in so doing, the Board has accepted no single forecast, but has projected the experience of the past 50 years to the end of the century. From the data of Fig. 1, it may be observed that consumption increased from approximately 340 mgd in 1898 to an average of 1,203 mgd in 1948 and that the straight line of average consumption indicates a rise of approximately 18 mgd per year. Thus, it has

been assumed that the demand for water in the year 2000 will be approximately 2,160 mgd.

One additional factor taken into consideration in developing the forecast based on Fig. 1 was the effect of the 1949 water shortage. The Department of Water Supply, Gas and Electricity was so successful then in its conservation campaign that consumption was reduced approximately 300 mgd. Moreover, some of those savings will apparently be permanent. For example, through the department's enforcement of more stringent regulations for the use of water in air conditioning, many industrial plants found that they could either reduce the use of water in this process or that, by revamping their piping systems, could reuse water which had formerly been wasted. Instead of projecting the prediction of future demand on a straight line, therefore, the Board assumed that one-third of that conservation saving is a permanent economy, and the forecast of future demand has accordingly been reduced by 100 mgd. That estimate, incidentally, is conservative, as the saving still observed is between 130 and 150 mgd.

### Search for Additional Sources

The recommendation contained in a report by the Board of Water Supply in December 1947 was accepted by the

\* Interstate Commission on the Delaware River Basin.

city, which directed the Board to initiate studies on the development of an additional source of supply beyond Stages 1 and 2 of its own Delaware project (1). A New Sources Division was established and headed by a board of consulting engineers.

As a result of the division's studies, the development of the West Branch of the Delaware River was recommended and adopted as the third stage of the Delaware project. This stage is called the Cannonsville project, because the site of the dam is just below Cannonsville, N.Y. That project is estimated to yield 388 mgd at a total cost of \$140,000,000 for the reservoir and the pressure tunnel connecting it with Rondout Reservoir. At a safe yield for municipal use of 323 mgd, the unit cost to New York City will be approximately \$60 per mil gal delivered, the cheapest additional one that the city can possibly obtain. Cannonsville water is upland water, truly comparable with the raw water that is obtained from the present Catskill system. Its elevation is such that delivery to the city is entirely by gravity.

Because of the limitations of a Supreme Court decree (2), only Stages 1 and 2 of the original Delaware project can be built. Stage 3 originally contemplated the development of the Beaverkill, the Willowemoc and the Little Delaware, three separate developments with a total safe yield of 160 mgd. Recent studies showed that the unit cost of these three separate small developments, with their smaller yield, was very much greater than the cost of the larger single development at Cannonsville. Furthermore, if the original Stage 3 as recommended in 1929 were completed, the quantity of water obtained would not equal the unallocated carrying capacity of the

Delaware Aqueduct, which amounted to approximately 360 mgd. The Cannonsville project, however, met that requirement and provided a complete answer to the problem.

To date the Cannonsville project has been approved by the city's Board of Estimate and the state's Water Power and Control Commission. An amendment of the Supreme Court decree is now necessary to permit the city to divert water in addition to the 440 mgd now authorized. Cannonsville is the one official project of the board that is scheduled for immediate action.

#### Arrangements for a Joint Project

In 1949 the states of New York, New Jersey and Pennsylvania, through Incodel, made an engineering study on the possibilities of a joint project to develop the resources of the Delaware Basin above Trenton, N.J.

The report of this study (3) indicates that, of the total water provided in the first stage of the Incodel project, a tentative allotment of 240 mgd had been made to New York City. With the completion of the second stage, an additional allotment of 270 mgd would be made, providing a total of 510 mgd of additional water available to the city.

Figure 1 shows that the safe yield at the end of the second stage of the Delaware project, when completed in 1956, will be 1,440 mgd. If the Cannonsville project is approved, the safe yield will be increased to approximately 1,800 mgd, which should provide an adequate supply up to and just beyond 1985. In its first stage, however, the Incodel project would add 240 mgd to the 1,440 making 1,680. The 270 in its second stage would bring the total to 1,950 mgd. The projected demand curve in Fig. 1 indicates that the demand in the year 2000 will be approxi-

TABLE 1  
*Sources and Yields*

Key Ltr.	Source	Yield—mgd	Key Ltr.	Source	Yield—mgd
A	Croton	270	H	Croton	330
	Long Is. Munic.	90		Long Is. Munic.	80
	Private Companies	16		Private Companies	40
	Richmond	9		Richmond	5
	Bronx Byram	10		Bronx Byram	10
TOTAL 1898-1904		395	TOTAL 1946-50		1,055
B	Croton	280	I	Croton	330
	Long Is. Munic.	120		Long Is. Munic.	80
	Private Companies	25		Private Companies	40
	Richmond	9		Richmond	5
	Bronx Byram	10		Bronx Byram	10
TOTAL 1905-08		444	TOTAL 1951-52		1,120
C	Croton	300	J	Croton	330
	Long Is. Munic.	140		Long Is. Munic.	80
	Private Companies	30		Private Companies	40
	Richmond	10		Richmond	5
	Bronx Byram	10		Bronx Byram	10
TOTAL 1909-16		490	TOTAL 1953-56		1,225
D	Croton	300	K	Croton	330
	Long Is. Munic.	140		Long Is. Munic.	80
	Private Companies	30		Private Companies	40
	Richmond	10		Richmond	5
	Bronx Byram	10		Bronx Byram	10
TOTAL 1917-23		790	TOTAL 1956-65		1,440
E	Croton	300	L	Croton	330
	Long Is. Munic.	140		Long Is. Munic.	0
	Private Companies	30		Private Companies	0
	Richmond	10		Richmond	5
	Bronx Byram	10		Bronx Byram	10
TOTAL 1924-26		910	TOTAL 1966-2000		1,800
F	Croton	300		Croton	330
	Long Is. Munic.	140		Long Is. Munic.	0
	Private Companies	30		Private Companies	0
	Richmond	10		Richmond	5
	Bronx Byram	10		Bronx Byram	10
TOTAL 1927-43		990	TOTAL 1966-2000		1,800
G	Croton	315		Croton	330
	Long Is. Munic.	100		Long Is. Munic.	0
	Private Companies	50		Private Companies	0
	Richmond	10		Richmond	5
	Bronx Byram	10		Bronx Byram	10
TOTAL 1944-45		1,020	TOTAL 1966-2000		1,800

mately 2,000 mgd. Thus, if the Incodel project were approved by the four states involved and if a joint commission were created to build it, it would provide to New York City an

ter, because, to connect Cannonsville only a pressure tunnel to the Rondout Reservoir need be built. The capacity of the Delaware Aqueduct from Rondout Reservoir to Kensico would take

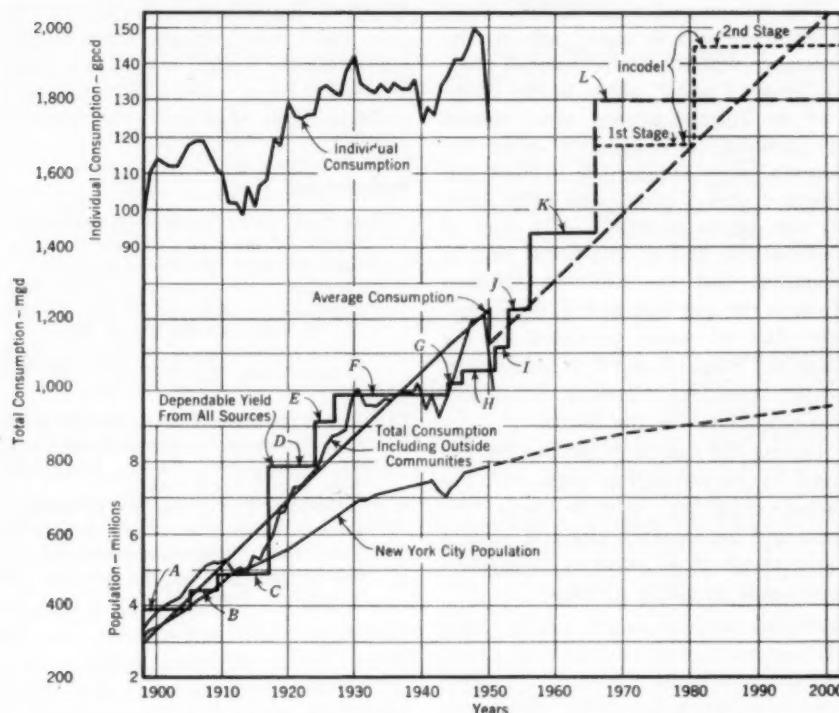


Fig. 1. New York City Population and Water Use, 1898-2000 A.D.

Actual past population and water consumption figures are shown by the solid portions of the respective curves. Estimated future figures for these factors are indicated by the broken lines. Key letters refer to horizontal steps of dependable-yield curve as explained in Table 1.

additional supply of upland water which would practically guarantee an adequate supply to the year 2000.

#### Comparison of Projects

The cost of Incodel water would be greater than that of Cannonsville wa-

this additional water from Cannonsville. The one hurdle is the Supreme Court.

As the Cannonsville reservoir is identical in both projects, the Board of Water Supply will recommend to the Board of Estimate, if the joint project is approved promptly, that

New York City turn over the Cannonsville Reservoir to the joint project at cost (4). It is of mutual advantage, therefore, for the neighboring states to join New York in a petition to the Supreme Court.

The recommendation to the Board of Estimate will be made only on the assurance that the entire Incodel project, Stages 1 and 2, will be built. Stage 1 of the Incodel project alone cannot be justified as compared with the Board's own Cannonsville project, but Stages 1 and 2 plus some other supply can be so justified. The cost of Cannonsville and an additional supply, assuming that the polluted Hudson River is the only source left, would exceed that of water provided by the combined Stages 1 and 2 of the Incodel project. Incodel, therefore, is the second possibility for the future.

During the course of studies for Incodel by its consulting engineers, the Board's staff kept in close touch with them and the Board's data and reports—the result of 45 years of research—were made available to them.

To make adequate provision for New York City's future water supply needs, either the Cannonsville project or the Incodel project must be the next step beyond the present Stages 1 and 2 of the Delaware project. The Board of Water Supply hopes that the four states will combine their efforts and, through a pact, create this joint Delaware Basin commission to start building both stages of the Incodel project.

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## Geophysics and Water

**By J. Frederick Stickel Jr., Loren E. Blakeley, and  
Bernard B. Gordon**

*A panel discussion presented on Oct. 26, 1951, at the California Section Meeting, San Francisco, Calif., by J. Frederick Stickel Jr., Engr. in Charge of Geophysical Services, Dames & Moore, Foundation Engrs., Los Angeles, Calif.; Loren E. Blakeley, Cons. Civ. & San. Engr., Orange, Calif.; and Bernard B. Gordon, Sr. Civ. Engr., East Bay Municipal Utility Dist., Oakland, Calif.*

### Geophysical Methods—J. Frederick Stickel Jr.

THE recent concept of geophysics in its relation to oil exploration has been that of an extremely valuable, economical method of locating more petroleum reserves without drilling thousands of expensive, misplaced holes. This tool of the oil industry can also be put to use in locating water or areas favorable for its accumulation. Oil is actually a luxury, but water is a necessity, not only for life, but for sanitation and industrial purposes. Much more water than oil exists on this planet, but, in densely populated areas, the water supply seems to be dwindling at a surprisingly fast rate. In some cities, sources that were marked for use in the distant future must be used to supplement the meager current supply. Water is probably just as plentiful as it was hundreds of thousands of years ago, but it does not seem to be located in the right places. This condition is no one's fault—it just exists.

Geophysical surveys are not necessarily substitutes for the old, established methods of exploration—they are merely supplements. They are used

to evaluate quickly and economically the possibility of the presence of water. The realization of this fundamental principle by prospective employers of geophysical services will not only place these methods in their proper light, but will lead the way toward a full understanding of the problems involved.

Two of the most common geophysical methods used in the exploration for water are the seismic and the electrical. These methods function in an entirely different manner, as they measure completely unrelated ground properties. Other methods are used, but perfect field and geologic conditions are necessary or the information that is derived from them cannot be properly evaluated. Even then, the interpretation is not as direct and conclusive as when the first two methods are employed.

### The Seismic Method

The seismic method measures the velocity of a wave which is instigated by an impact on the ground or the explosion of a small charge of dynamite

buried beneath the surface. A simplified field setup for seismic determinations requires the placing of the explosive in a 6-ft shot hole and distributing the seismometers or detectors at equal intervals in a straight line from the shot point. The spacing is determined by the character of the subsurface material and by the depth to be determined. The most satisfactory results are obtained with instruments that have twelve or more detectors. Vibrations will pass slowly through loosely compacted material, and more rapidly through compact or dense material.

When the shot is fired in the shallow shot hole, the vibration waves move out in all directions, forming a curved wave front. At the instant that the wave front reaches the seismometer closest to the shot hole, the instrument is at a point tangent to the wave front, and is oscillated. At the same instant, the wave front also reaches a point beneath the shot point approximately the same distance as that between the first seismometer and the shot point. This relationship is true throughout the line of seismometers. It follows, therefore, that if the seismometers were all placed so that they were equidistant from the shot point, and in a circle, the arrival times of the curved wave front at each seismometer would be simultaneous. On any survey, this configuration is usually carried out numerous times at various locations to determine the average velocities of the top, or first, material encountered. The arrival times of the wave front are measured in thousandths of a second. These times are plotted on a time-distance chart against their corresponding distances from the shot point, and the velocities and depths of velocity

changes are computed and correlated with existing geological conditions.

### **Electrical Methods**

In many respects electrical methods are unique. They were mainly developed for prospecting, whereas the other geophysical methods are by-products of earlier research into pure science and other usages. Electrical methods are more empirical than the other methods which are substantiated by theory. The degree of accuracy on some shallow surveys is nevertheless remarkable. Electrical methods involve a greater variety of techniques than the other geophysical methods. So many variations exist that only a general explanation of the electrical resistivity method will be discussed.

Basic instrumentation is the commutated direct current used by Gish and Rooney, early developers of the method. The Wenner configuration and slight modifications of it are the most common electrode arrangements used today. This configuration consists of four electrodes that are set in the ground in a straight line, spaced at equal distances. The current is then directed to the two outside electrodes, and the potential drop is measured on the two inside ones. The values are read directly from the instrument in ohm-centimeters of apparent resistivity. The electrode spacing is closely related to the depth to which the resistivity is affected by the subsurface materials. These resistivities are plotted on an ohm-centimeter-distance curve, and the resistivity changes are noted and correlated with actual conditions.

### **Location of Water**

Water is one of the minerals that geophysics can locate directly, because unconsolidated substances such as

gravel and sand have a greater seismic velocity when wet than when dry. It is this water table condition that lends itself successfully to seismic prospecting. Electrical resistivity is also based on the same general qualities. Gravels and sands that are saturated with water have low resistivities, whereas the non-water-bearing gravels and sands have high resistivities. The amount of fine clay and silt dispersed throughout a gravel or sand, however, has a direct bearing on the resistivity of that material. It is sometimes possible to detect a certain material by means of its velocity or resistivity. In areas in which geologic control is established, geophysical surveys will complete the subsurface picture, and more perfect drilling control will be possible.

Valleys and outwash areas are potentially good sites for use of geophysical methods not only for the direct location of the water table, but for determining subsurface valley structures that will probably contain water. Valleys filled with glacial till and alluvium are ideal locations for geophysical water prospecting. The use of geophysics in exploring other types of structures is not necessarily limited, however. Porous, water-bearing bedrock formations may also be found and surveyed for their ultimate use as water sources.

The geology of the northern peninsula of Michigan is that of pre-Cambrian formations containing preglacial valleys that were gouged out by glaciers and subsequently filled with glacial gravels and sands. As this material is very permeable and contains water throughout the year, shaft-mining operators in the area are perpetually faced with the problem of diverting ground water from the shafts and rich ore areas. Flooded mines cause a loss in ore potential. The placing of surface

wells up the valleys from the shafts was decided upon to relieve this costly situation. Seismic surveys disclosed bedrock contours, which made drillhole location simple. The investigations showed that, in the fall, the water table is approximately midway between the ground surface and bedrock. The seismic velocity in the upper dry gravels and sands is 2,000-3,000 fps, and in the water-saturated gravels and sands directly beneath is 5,000-6,000 fps. After this comprehensive study of the bedrock configuration, drill holes were placed in critical areas so that the water might be brought under control at the surface and diverted into non-ore-bearing valleys or to abandoned workings. The velocity in bedrock varied from 12,500 to 20,000 fps.

The state of Massachusetts uses seismic surveys in finding the water table for community water supply and also in highway construction.

#### Location of Favorable Areas

Seismic and electrical surveys sometimes cannot be correlated with the water table. Profiles and depth determinations are therefore used to find areas that will favor water accumulation. The thickest glacial or alluvial deposits above bedrock are indicated to be possible water bearers.

Electrical surveys have been conducted by the Illinois Geological Survey for many years to supplement the water supplies of growing communities. In the Champaign-Urbana, Ill., area, electrical well logging, electrical earth resistivity surveys, geology, and test borings have been combined to exploit the ground water resources fully, for public and industrial use. This area contains little or no bedrock exposures or outcrops, so subsurface information was derived entirely from

geophysical data and drill logs. The electrical surveys proved to be very valuable.

Seismic experiments conducted in southern Michigan have located water-bearing gravel and sand lenses in the clay which lies above bedrock. The lake-clay deposits in this area are intermingled with the glacial material to approximate depths of 100 to 150 ft below the surface. In this region, considerable experience and experimenting are necessary to produce satisfactory results, but seismic surveys have been satisfactory and are economically feasible.

### Other Methods

Another geophysical instrument which has been used to locate subsurface valleys that offer no surface indication is the magnetometer. Most of the surveys conducted with this device were carried out in the western states to locate subsurface channels that contain gravels bearing such metal as gold. Only the presence and trend of the channel may be detected with the magnetometer. Actual depth determinations are possible, but the cost of the field work and computations to calculate them is usually prohibitive.

By a series of experiments conducted in the last decade, the state water board of Ohio, attempted to locate, by the use of radio waves, the preglacial valleys that are potential water sources. Radio reception was affected, however, not only by subsurface structures but by the various soil types. Fertile soils with a high moisture content absorb less radio energy than less fertile dry soils. In the experiments, it was discovered that the anomalies—or valley indications—present were the result of reflections from bedrock as

well as of absorption due to glacial drift. Topography also affected the readings, and, therefore, accuracy of interpretation was questionable.

### Foundation Investigations

Geophysics has value not only in the location of water or the location of areas favorable to water accumulation, but for the determination of subsurface conditions in foundation investigations for water plants, tunnels, aqueducts, pipelines, and dams.

Geophysical surveys have been used to determine foundation conditions for plant sites throughout the world. Although drill holes on a prospective site are a necessity to determine the future differential settlement of the completed structure, the holes are located with the aid of geophysics. Geophysics are used in determining the extent of fill areas—an absolute necessity in building or plant construction. In tunnel, aqueduct, or pipeline construction, it is desirable to know whether a consolidated rock or an unconsolidated material will be encountered.

In South Carolina the determination of the extent of a wet fill area was necessary, because a large building was to be located half on the fill and half on solid dry ground. This determination was made by a seismic survey. A Birmingham, Ala., contractor was interested in knowing whether the tunnel he was to construct would be driven in limestone or clay. A seismic survey along the centerline of the tunnel showed that approximately 75 per cent of the tunnel would be driven in limestone and 25 per cent in clay.

### Conclusions

The various geophysical methods have all been tried throughout the

years, but the most common, reliable, and economical are the seismic and the electrical. The geophysicist must thoroughly evaluate these methods to enable himself to recommend the proper one for each specific job. Experience shows that each project presents new and different problems, for no two projects are identical. General rules are followed and coordinated with the conditions present. Details are variable and must be properly evaluated in accordance with sound geological or instrumental explanation. It is easy to be misled by geophysics, and the practical applications of the science should be examined intelligently, with an understanding of its limitations.

Geophysical surveys are considered successful when the actual conditions are comparable with predetermined theoretical conditions. This relation,

coupled with the experience of the geophysicist, will present a final satisfactory result. The geophysicist must be able to think in terms of localized, near-surface geologic structure and problems. It must be understood, however, that the field of geophysical engineering is in its infancy. The cost of this type of exploration varies from \$300 to \$600 a day, depending upon the extent of the area to be surveyed, amount and type of personnel necessary, availability of the site, and depth beneath the surface to which information must be derived. The money spent on geophysical surveys, however, is far less than that spent in haphazard procurement of information by other slower methods. This science is not a cure-all but merely another type of scientific reasoning applied to practical use.

### **Seismic Methods—Loren E. Blakeley**

**G**EOLOGY in its many branches was a little known science when most of the water supply projects in the West were started. Engineers then were hardy souls who wore long leather breeches. Water was where it could be seen, and long aqueducts and other works which provided for surface storage and gravity transmission lines were standard.

It is now becoming recognized that California's population is living on the porous roof of the state's greatest natural asset—its vast underground reservoirs of water. Wells have been drilled at an ever-increasing rate to tap this supply. Indiscriminate dumping of the wastes of civilization has been stopped by legislation which is based on the firm antipollution policy

of the AWWA California Section and allied organizations. As members of the leading industry of the state, water works men now have to consider the future and, at the same time, attend to the daily operation of their business.

Seismic exploration of critical parts of the underground reservoirs offers an extremely valuable method of "listening" a little further into the earth than man has been able to do in the past. Experience in the use of this method has convinced the author of its value. The amount of information gained per dollar spent is, of course, the practical yardstick. This standard should appeal to even the most hard-headed management in the business. One has only to look at cost accounting records now to see the expense of pneumatic

drilling or other time-tested methods of sinking test holes.

### Shallow Bedrock Determinations

A few examples of simple explorations may be of interest not only because of the specific findings, but also because they indicate what others may find elsewhere.

One small canyon near Los Angeles has long been used for recreational purposes. Several dams have been built, both of earth and concrete. Most of them leak, and, in years of light rainfall, the underflow is insufficient to maintain the usual water level. After approximately 40 years' experience with the arts and practices of dowsing, the author considered and discarded this method of locating the underground streams of which engineers in a farming community so often hear. A project to make one dam impermeable was effected by the standard procedure of driving pipes to apparent bedrock to inject Shellperm\* asphalt emulsion. The work was not successful in securing water shutoff although more than 150 ft of concrete dam and earth abutments were treated.

Portable seismic geophysical equipment was then brought in. Geophones showed the existence of two hidden valleys approximately 50-75 ft beyond both ends of the concrete dam and treated abutments. This bedrock was only 5 ft deeper than was indicated by the row of test holes. Below the rocks encountered in drilling was material later identified as coarse rectangular grained sand with no clays or colloidal material and, of course, this sand is very pervious. One day's use of geophysical equipment before construction was started would have shown the hid-

den ridges and valleys and would have enabled proper estimation of the volumes and distances involved.

In the search for additional water for a small mountain school, profiles were run both down and across the canyon. Results on this survey showed bedrock from 9 to 25 ft below ground surface, with no more recoverable ground water on the school property. It was necessary to install an ample storage tank and haul water during months when the original dug well was dry. This seismic work and engineering investigation was performed after—instead of before—nearly \$3,000 had been invested in the drilling of a 160-ft well which tapped water containing 2,400 ppm of chlorides in an old sandstone formation.

### Basin Boundary Determinations

Other areas in southern California in which geophysical methods have been used include the Pasadena basin, where an unknown alluvium-filled valley was found at a point where well log data were scarce. At another site in that basin, early core-drilling data on pier locations for a state highway bridge were checked to within a fraction of a foot.

Recommendations for seismic survey of a nearby ground water basin in southern California were rejected because the work was not performed as a free demonstration for the city. The community spent many thousands of dollars, however, on a new well that was drilled just 60 ft on the wrong side of an old producer. Instead of tapping the recent alluvium and water-filled gravel, the engineers drilled into a hidden plateau of absolutely dry, old alluvium, and the casing had to be pulled out. Seismic exploration of faulted and eroded canyon basins such as this one, when coupled with study

\* A process patented by Shell Oil Co., Inc., New York and San Francisco.

of existing well-log and hydrographic data, provide knowledge upon which proper well spacing may be based. In this particular basin, probably only four velocity breaks would occur, ranging from 2,500 to 25,000 fpm from coarse surface gravel to granite bedrock. Definite limits of recoverable ground water, in both vertical and horizontal planes within the basin could then be accurately determined, and underground storage capacity, points of overflow into the lower basin, and economical well sites could be estimated at little expense.

Use of seismic methods has been recommended for the San Luis Rey and Santa Margarita river channels, where it is believed that ocean water is being drawn inland by the heavy pumping. The location of sand and mud deposits in San Francisco Bay has been determined by seismic methods. In that operation, geophones were floated by inflated tubes, and the entire operation was executed by boat much more cheaply than is possible with any other known method of exploration.

### Quality Determinations

It is possible to combine ground water hydrology and geophysics. Intrusion of saline waters can sometimes be detected by both seismic and electrical methods. This combination offers an opportunity to gain much information on the location, depth, and quality variations of water as density or conductivity layers increase within a forma-

tion. Such surveys would perhaps be of greater value in a 3-mile gap such as the one that exists at the mouth of the Santa Ana River in Orange County than drilling of test wells every few years to pick up the salt water front, which is advancing approximately 700 ft a year. The cost of one well would pay for several thousand feet of profile in both directions. Many other valleys along the California coast are similarly affected. In Orange County, the seismic method has even been known to detect a fault face in recent gravel formations along the coast.

Hundreds of other practical examples of the use of the geophysical method can be cited. It has been proved both in the laboratory and in the field. As in many other fields of private enterprise, the question so often raised is, "How much will it cost?" The question which management should ask is, "How else can so much be obtained for so little?"

### Conclusions

The use of geophysical methods in ground water investigations is here to stay. Employment of consultants to work with local engineers and field men who are acquainted with local basin conditions offers management the most economical way of gaining desirable data on critical areas. Proper budgeting for such purposes should be practiced so that the most efficient use can be made, both of available equipment and of the men who are trained in this particular field of investigation.

### Electric Resistivity Method—*Bernard B. Gordon*

**T**HE property of electrical resistance for both rocks and soil has been utilized for engineering purposes in developing a method of exploring under-

ground geological formations. A full-scale trial of this technique has been made by the East Bay Municipal Utility Dist.

To understand the application of the method, a general appreciation of the basic principles is desirable. Resistivity surveying essentially involves field application of Ohm's law. Resistivity has been defined as "the specific electrical resistance of the medium to a flow of a steady electrical current along a unit length of path of unit cross section," and it is usually expressed in ohm-centimeters or ohm-feet (1). The value varies—as can be expected—with density (or porosity) and with degree of saturation. The variation in resistivity must largely depend on the water in the pores, as both the solid and gaseous states of most soils and rocks have high resistivity. Dense crystalline rocks such as limestone and granite generally have high resistivity values; sand and gravels which are of intermediate porosity have intermediate resistivity; and clays and shales which have high porosity and a relatively great proportion of soluble electrolyte have low resistivity.

#### Resistance-Difference Measurement

It has been shown that differences in resistivity are measurable, and, by such measurements, changes in underground conditions can be determined (2, 3). Various methods have been used in the field with success. Each is best suited to some particular type of exploration. For soils and foundation exploration, a four-electrode system using direct or periodically reversed low-frequency current has been found best. This method, known as the Wenner-Gish-Rooney approach, requires that the four electrodes be set in a straight line and spaced at equal distances. A current is passed between the two outer electrodes, and the potential is measured between the two inner ones. Increasing the spread between electrodes

increases the current-distribution hemispheres and deepens the penetration of the current flow lines. The ground resistivity in a zone between the potential electrodes, P1 and P2, can be measured. The resistivity  $\rho$  is determined by:

$$\rho = 2\pi a \frac{V}{I}$$

in which  $a$  is the distance, in feet, between electrodes,  $V$  is the voltage in millivolts, and  $I$  is the current in milliamperes.

In practice, the resistivity found is taken as a measure to a depth equal to the electrode spacing. If a series of readings are made at increasing electrode spacings, the resulting apparent resistivities will be characteristic of conditions at increasing depths. Such a method is similar to electric drilling at a single point, and results can be interpreted to give the variation of materials at different depths. This method is known as "depth profiling" and is the common way of determining foundation conditions. If a constant electrode spacing is maintained and used with a large number of points along a line or a grid, a condition of electrical trenching will result, and underground conditions will be checked at constant depth. This method is best adapted to outline horizontal changes in the subsurface and is excellent for interpolation between drill holes.

#### Equipment and Interpretation

The equipment (Fig. 1) for the typical Wenner-Gish-Rooney method includes: [1] a measuring unit composed of a milliammeter and a potentiometer, [2] a power supply consisting of either direct or low-to-intermediate-frequency alternating current (as much as 250 v are required in foundation

work), and [3] electrodes, leads, and reels.

Field application of the resistivity method is relatively simple after a crew has been trained in the work, but interpretation of the data is a much more difficult process and requires special training. A major qualification is general familiarity with the geological formations to be encountered. Methods of interpretation are many but the most reliable include either empirical plotting methods or comparison with published sets of master curves that are based on solutions of theoretical equa-



**Fig. 1. Equipment**

*This equipment was used in the field application of the Wenner-Gish-Rooney method of exploration.*

tions with assumed values. The use of master curves is more satisfactory for foundation uses, although the former approach has worked with shallow explorations.

In interpreting the field data, it must be remembered that all the material from the surface of the ground to a depth equal to that of the electrode spacing affects the resistivity determination. At greater depth, therefore, the resistivity changes gradually; hence the exact contact of the various layers cannot be determined. The rate of change (increase or decrease) in the

resistivity with change in electrode spacing should be noted.

When resistivity is plotted against electrode spacing, the resulting curve has a shape that is a result of the change in resistivity with depth. As the shape of this curve is related to changes in soil conditions, any method of plotting which results in families of curves of different shapes is of value in the interpretation of readings.

An arithmetical method of plotting is sometimes used, with the break in slope being interpreted as the depth of a change in strata. A variation of this method involves the plotting of cumulative values of the apparent resistivity in comparison with electrode spacing on a linear graph (4). The graph will contain linear sections of different slopes which are joined by curved sections. Tangents drawn through the linear portions of the curve will intersect at points from which values of the electrode spacing are taken as the depth of a boundary between media of different resistivities. This method has been used successfully in exploring for deposits of construction materials.

The method used by the East Bay district involves a double logarithmic plot in which the resistivity plotted against electrode spacing yields curves of characteristic size and shape, independent of either resistivity units or electrode spacing. Interpretation is then a matter either of visual inspection or of comparison with families of master curves.

Two different sets of master curves are available. One set has been calculated on the basis that the earth for the depth considered is a two-layer material (5). The other calculation assumes a three-layer material (6). Published data are not available for

other factors because the basic equations are too unwieldy and the method of interpretation impractical. The interpretation now becomes a matter of matching the field curves to these master curves and applying the data thus obtained to certain simple equations. Experience and judgment are vital at this stage, because various combinations of master curves that will give erroneous results are always possible.

### Trial Application

In the fight against corrosion and electrolysis, electrical resistivity surveying has been used as a tool by the district and predecessor water companies since 1922, but application of the technique to soil and foundation exploration is a recent development. This development was brought about by dissatisfaction with existing methods, particularly those for reservoir and storage tank foundations in complicated geological areas.

Much of the territory covered by the district includes the warped and twisted Franciscan sediments in the hills to the east of Berkeley and Oakland. The region is characterized by geological confusion with extreme variations in foundation conditions occurring within very small areas. The district has under way an expansion of the distribution system which includes, in particular, a number of reservoirs. Choice of possible sites for land acquisition forms an important step in the program. Ordinary methods of foundation exploration such as drilling, probing, or trenching proved either impractical or too expensive for the limited results obtained.

A rapid and inexpensive method was needed for roughly surveying an entire area under consideration and for determining those points at which detailed

information was required. Resistivity seemed to offer the best solution, because a grid of depth profiles could be made at close intervals, and from these an underground contour map could be prepared. With such a map as a guide, an intelligent selection was possible in locating test borings or trenches.

### Test Site

After several preliminary surveys, a full-scale trial of the method was made in 1950 at the proposed site for a large, open storage reservoir. At the time of the survey, a 20-acre reservoir was contemplated, to consist of three large, open, concrete-lined basins with walls to be formed partially by excavation and partially by earth embankments. Total capacity was to be approximately 140 mil gal, and each basin was to hold approximately one-third the total. No rock exposures existed in the area, although a small outcrop of rhyolite occurred just beyond the limits of the site. The general contour of the hills indicated the probable presence of sandstone.

The survey was planned to locate the depth for a satisfactory foundation for the reservoir. The reservoir was to be set in a relatively narrow east-west valley with the three basins abutting each other and lined up in the direction of the valley. The investigation was confined to Basin 1, an area of approximately 350,000 sq ft.

### Technique, Personnel, Equipment

The multiple transverse technique, which is a combination of depth profiles made along a traverse, was selected. Field work was done by a crew of four from the district Soils Laboratory with apparatus borrowed from the Materials and Research Laboratory, California Div. of Highways.

The equipment was of the four-electrode Gish-Rooney type and had been constructed in the district laboratory. The measuring unit comprised a milliammeter and potentiometer with a reversing switch to allow changing direction of current and a selector switch for selection of order of reading the potential electrodes. The power unit consisted of four 45-v "B" batteries connected through a selector switch so that  $22\frac{1}{2}$ -v steps could be used. A rheostat was included for fine adjustment of input-current readings. Porous porcelain pots which contained a copper sulfate solution were used for the nonpolarizing potential electrodes, whereas steel rods were used for current electrodes.

A base line was established along the axis of the valley and staked at each 100-ft station. Offsets were laid out at 100-ft intervals to the right and left of the line. The measuring and power units were placed on the tail gate of a station wagon which was located at one of the grid points. Two 50-ft tapes were joined at a grid point with a chaining pin and stretched out along a contour in opposite directions. Electrode interval was then laid out by two stake men so that the four electrodes were at three equal spacings and symmetrical with respect to the grid points. Electrode spacings of 2, 3, 6, 10, 12, and 40 ft were used except in localities where the trend of the curves indicated greater depth. Spacings of 60 and 100 ft were used in the latter areas.

At completion of each reading, current and potential were reversed, and a reading was taken in the opposite direction. The double reading eliminated reading errors and compensated for the effect of stray ground currents. The data were plotted on transparent

double logarithmic paper (2 $\frac{1}{2}$  cycles by 2) with apparent resistivity as ordinate and electrode spacing as abscissa. Trends of the curves were studied for similarities by using master curves for both the two-layer and three-layer systems. Absolute values of resistivity were determined for the top three strata, and these values were used as a guide throughout. For every curve, each stratum was identified, and the depth to the boundary was determined. Results were plotted on a topographic map of the area and contours of the underground strata were sketched out.

The results indicated that, for the depth studied, the soil profile was composed of three general layers or strata. The top of the second layer was from 2 to 5 ft below the surface. Surface contours of the third layer showed the presence of a buried channel as much as 20 ft deep, cutting roughly north-south across the basin.

#### Identification and Physical Tests

As this survey was made as part of an experiment in electrical surveying, it was evident that conclusive proof of the finished underground contour map would require actual trenching operations to uncover the various layers for identification and physical tests. Two locations were selected at which the contours indicated that shallow trenches would reveal all three surface materials to the eye. A tractor with a bulldozer blade to which cutting teeth had been welded was used to dig two long, shallow trenches. Three distinct layers were uncovered, just as predicted, with depths substantially as shown by the contour map.

The resistivity map had indicated a thin surface crust of medium resistivity, a layer beneath it of lower resistivity and very shallow depth, and an un-

determined depth of higher-resistance material believed to be rock. As revealed on the faces of both trenches, the soil profile had a layer of chocolate brown, silty loam, rather loose and porous and penetrated by roots. Beneath it was a more dense, tan to light brown, sandy clay which contained occasional chunks of unweathered sandstone and small, black concretions. The material changed gradually into a very hard, dense, light brown, sandy clay with a much embedded rock, mostly a water-deposited, rounded, cherty gravel,  $\frac{1}{2}$ -in. and larger in size. This latter material could be classified as a hardpan, and was so tough that the bulldozer could barely cut it.

### Results of Verification Survey

The overall results of the verification survey were very satisfactory and proved that, when properly applied, resistivity surveying would faithfully indicate changes in the soil profile. None of the three strata was actual bedrock, although the material at the bottom of each trench was so hard that it could be considered soft rock.

The predicted elevations did not check exactly with the trenching. This result indicated [1] that the grid system must be staked out carefully, and correct surface elevations must be obtained for each grid point, and [2] resistivity surveying yields results that represent an average from the surface to the depth checked, and cannot be interpreted as an exact depth to a change in material.

Trenching to the full depth of the indicated channel was not considered practical. At the time that the experiment was being conducted, however, a U.S. Geological Survey geologist was engaged in remapping the quadrangle in which the district survey was being

made, and confirmed that he had found several indications of an old drainage pattern oriented in the same direction as the buried channel. This ancient drainage was undoubtedly responsible for washing down the rounded cherty gravel found embedded in the clay matrix at the bottom of both trenches. As the only known chert beds in the area were those capping the adjacent hills, and, as the gravel was of considerable size, it was evident that the flow of the old stream had been considerable at one time.

The experimental survey clearly indicated that the electrical resistivity method could be utilized for reconnaissance surveys for open reservoirs, tanks, and other such construction. The method even proved sensitive to changes in density and water content in the overburden. Determination of depth to bedrock would have required the use of profiles of greater depth, but this information would have only been of academic interest, as the third stratum is eminently suitable for a foundation for the type of construction proposed.

### Costs

The economies of this type of operation were well evidenced. Once the "shakedown" period was finished, as many as twelve 40-ft depth profiles could be made in one 8-hr day—the equivalent of 480 ft of borings. In all, 51 depth profiles were made, an average of eight per day. Total time spent on the job included 24 man-days in the field, including travel time, and 6 man-days in the office. Cost of a four-man crew—an engineer, an inspector, and two aides—with equipment, should not exceed \$100 per day. At this rate, the electrical-borings cost approximately 35¢ per foot. The minimum

cost for soil borings of any type is \$2.00 per foot. On this job, one profile was made for each 7,000 sq ft of area.

### Conclusions

As a result of this experimental investigation and several other test projects, the district has been convinced that the electrical resistivity method has merit for additional use in their engineering work. It is fast and cheap and can be used as a reconnaissance tool for determination of suitability of areas for property acquisition as well as a method for locating detailed drilling in preparation for actual construction. Further use of the method is proposed in investigations for reservoirs, tanks, dams, and other such construction.

The equipment available commercially varies both in complexity and price. The most desirable features are portability, ease of operation, and ruggedness. As economy is the keynote of the method, anything that speeds up the operation is desirable. Equipment suitable for this work ranges in price from \$500 to approximately \$2,000. Apparatus of the Gish-Rooney type has been ordered that comes packed in several light aluminum cases, including a measuring unit weighing 37 lb, a bat-

tery supply weighing 18 lb, and four reels, leads, and other equipment weighing 72 lb.

This method is currently most suitable for reconnaissance and, usually, verification of the results must be obtained by means of geologic mapping and soil borings. Even at such a site as that described, at which excellent foundation conditions exist, some method of obtaining samples was needed to identify the various materials positively and to evaluate soil strength.

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# Preliminary Studies of Underground Water at Wausau, Wis.

By Howard P. Potter

*A paper presented on Sept. 26, 1951, at the Wisconsin Section Meeting, Milwaukee, Wis., by Howard P. Potter, Project Engr., Jerry Donohue Engineering Co., Sheboygan, Wis.*

WAUSAU, Wis., will soon complete a half-million-dollar water works improvement consisting of three new wells (caisson type, gravel wall pack), three pumping stations with lime feed and fluoridation equipment, a 2½ mil gal prestressed concrete reservoir, and extensive installations of large-diameter water mains.

The heart of the improvement is naturally an abundant supply of good water. The Wausau Board of Public Works and Water Commission were determined to conduct sufficient preliminary investigations to insure the acquisition of such a supply—a farsighted, sensible decision. As a result of careful and adequate investiga-

tion, the city has acquired three excellent wells, one of which is said to be one of the largest-yield wells in Wisconsin.

## The Project

Plans and specifications required the sinking of 6-in. test holes from the surface of the ground to the granite, drilled in a manner to determine the thickness, area extent, and location below ground surface of each water-bearing formation within the depth and influence of the proposed wells. A complete log of the penetrated material, with a report on the formation analysis, water analysis, and water levels in each test well was required. The formation

TABLE 1  
*Characteristics of Test Holes*

Hole No.	Depth ft	Static Level	Draw- down	Screen Setting	Time Pumped hr
1	163	24	0	85-95	17
1	163	24	0	100-110	27
2	158	30	0	85-95	8
3	147	35	0	85-95	7
4	80	25	—	70-80	None
5	126	40	13	83-93	4
6	149	39	0	57-67	4
6	149	39	0	80-90	10
6	149	39	0	90-100	4
6	149	39	0	110-120	17

TABLE 2  
*Chemical Analyses of Water*

Hole No.	Material—ppm						pH Value
	Hard- ness	Alky.	Chlo- rides	Free CO <sub>2</sub>	Fe	Mn	
1	20	42	0	43	20.0	0	6.4
1	34	44	0	40	12.0	0	6.6
2	58	20	0	37	0.10	0	6.1
3	80	74	0	9	0.20	0	7.3
4	52	54	0	60	16.0	0.24	6.5
5	66	55	—	—	0.05	0	6.5
6	50	32	0	58	0.15	0	6.7
6	64	28	0	90	0.20	0	6.7
6	64	32	0	10	0.25	Tr.	6.7
6	62	54	0	31	7.0	Tr.	6.6

analysis included sieve analysis, porosity, uniformity coefficient, effective size, and permeability. Water samples were analyzed on the job site, and corresponding samples of water were also

the granite and the 10 ft of material immediately above the granite was plugged to seal off the water from this lowest formation. A 10-ft section of screen was later installed at the sec-

TABLE 3  
*Physical Properties of Water-Bearing Formations*

	Test Hole No.			
	2	3	5	6
Formation Test Depth—ft	68-114	60-130	78-98	66-123
Proportion Retained on Sieves—per cent				
0.034-mm sieve	12.0	20.0	0	0.5
0.030-mm sieve	2.0	3.0	0	0.5
0.026-mm sieve	2.0	3.0	0	0.5
0.023-mm sieve	12.0	9.0	0	5.0
0.021-mm sieve	10.0	6.0	0	6.0
0.017-mm sieve	11.0	5.0	1.0	7.0
0.015-mm sieve	22.0	15.0	12.0	29.0
0.012-mm sieve	17.0	16.0	38.0	28.0
0.010-mm sieve	9.0	14.0	36.0	16.5
0.009-mm sieve	—	1.0	2.0	2.0
0.008-mm sieve	—	1.0	2.0	1.0
0.007-mm sieve	—	5.0	6.0	2.0
Pan	1.0	2.0	3.0	2.0
TOTAL	100	100	100	100
Constant*	1/6	1/6	1/6	1/6
Velocity—cu in. per sec	3.50	3.0	2.24	3.25
Head Differential—ft	37	36	36	54
Recommendations for Final Well:				
Screen Setting—ft	60-100	60-100	68-98	67-97
Diam. Gravel Wall—in.	48	48	48	48
Gravel Size†	22	22	22	22
Estimated Yield—gpm	2,500	2,000	500	700

\* Value of permeability coefficient; depends on hydraulic properties of materials through which flow is taking place.

† Layne-Northwest Co. measurement No. 22 designates gravel between 0.049 and 0.0685 in. Many suppliers prefer to designate this size as 1.25-1.75 mm.

shipped to the state laboratory for similar tests and additional bacterial analyses. The test holes (except one which was abandoned early in the project schedule because of excessive iron content in the water) were drilled to

tions where log data indicated favorable possibilities, and the test wells were then pumped for several hours with a 50-gpm unit before a representative sample of water was withdrawn for analysis.

TABLE 4  
*Final Construction Sites*

	Well No.		
	1	2	3
Test Hole No.	2	3	6
Well Depth—ft	100	100	98
Screen Depth—ft	60-100	60-100	68-98
Screen Diam.—in.	24	24	24
Outside-Casing Diam.—in.	36	36	36
Outside-Casing Depth—ft	50	50	58
Grout Thickness Around Outside Casing—in.	9	9	12* & 9†
Gravel Wall Thickness—in.	12	12	12

\* First 20 ft.

† Next 28 ft.

The data compiled from the preliminary underground studies is briefly summarized in Tables 1-5.

Final well sites were eliminated at the locations of test holes No. 1 and No. 4 because of the excessive amounts of iron and at test hole No. 5 because of the lack of coarse material. Test holes No. 1-4 were located in an area at the northern edge of the city and test holes No. 5 and No. 6 in an area at the southern edge. Sites for the final construction are given in Table 4.

Table 5 shows the drawdown of water levels in the final pumping tests on the finished wells. After a study of these figures it was decided to install 1,500-gpm pumps in wells No. 1 and No. 2, and a 1,000-gpm pump in well No. 3.

TABLE 5  
*Drawdown in Final Pumping Tests*

Well No.	Depth—ft	Drawdown ft
1	Static Water	31.50
	After 8 hr Pumping at 1,500 gpm	46.50
	After 7½ hr Pumping at 3,000 gpm	57.0
	After 1 hr Pumping at 3,600 gpm	59.0
2	Top of Screen	62.0
	Static Water	36.0
	After 8 hr Pumping at 1,500 gpm	46.0
	After 8 hr Pumping at 3,180 gpm	61.0
3	Top of Screen	62.5
	Static Water	43.25
	After 2 hr Pumping at 550 gpm	48.25
	After 2 hr Pumping at 700 gpm	49.75
	After 4 hr Pumping at 1,000 gpm	53.25
	After 8 hr Pumping at 1,500 gpm	60.25
Top of screen		69.0

### Conclusions

That the cost of adequate preliminary investigating is a wise expenditure of funds is evidenced by the excellent results of the Wausau project. The total cost of the project was \$47,150, of which \$4,175 or 9.28 per cent was for test-well work.

The three new wells will discharge directly into the distribution system, and the city will be able to discontinue the operation of the existing filtration plant, which was constructed in 1927 to remove iron and manganese from the old ground water supply.

Savings in operating costs will soon pay for the costs of the new wells and all other improvements that were made during the past year.

# Well Improvement by the Use of Vibratory Explosives

By Harvey A. Mylander

*A paper presented on Oct. 25, 1951, at the California Section Meeting, San Francisco, Calif., by Harvey A. Mylander, Dist. Engr., Water Supply Analysts, South Pasadena, Calif.*

WATER from drilled wells is quite expensive because of the initial capital investment in property and well construction, maintenance costs, and continuous power costs. The quality, quantity, and unit cost of production of water from wells are naturally of primary importance. The well may be an efficient or inefficient producer if measured in terms of the usual standards, that is, in terms of its cost compared with revenue from the saleable commodity. If arithmetic reveals that the well is inefficient, the difficulty should be diagnosed and remedied.

## Sick Wells

Many wells lose productivity out of all proportion to the decline in the water table. Wells in which the drawdown, or the difference between static and pumping levels, increases faster than in other wells in the vicinity, might be termed "sick." The reason for this loss of productivity has been the subject of extensive scientific and operational analysis. As this increased drawdown causes a loss of pump efficiency and a greater pumping lift with a resultant decrease in water output, it is uneconomical to permit such a condition to exist.

Wells become sick from three principal causes: [1] "sanding-off" (a condition in which the productive zones

are buried in sand); [2] fines in the formation that seal off the coarser layers; and [3] obstructions, such as growths, deposits, and incrustation, in the perforations and formations.

## Conventional Redevelopment

The methods currently used by well drillers and well servicing firms to redevelop or reactivate wells are divided into chemical and mechanical processes.

Chemically, wells may be temporarily improved with acid, chlorine, and Calgon\* in varying dosages. The process always requires immobilization of the well for several days and adequate provisions to remove all agents afterwards. Chemical treatment is aimed only at specific types of growth and is only mildly effective on incrustation. Acids of sufficient strength to dissolve the mineral salts of the incrusting material obviously might be destructive to the metal of the pump and well casing.

Of such mechanical methods as surging, air lift, dry-icing, and swabbing, actual tests before and after application show that only swabbing is uniformly beneficial, and the results are short-lived. This method is expensive as the pump must be removed and re-installed, and several days' work with special tools must be performed inside

\* A vitreous phosphate; product of Calgon, Inc., Pittsburgh, Pa.

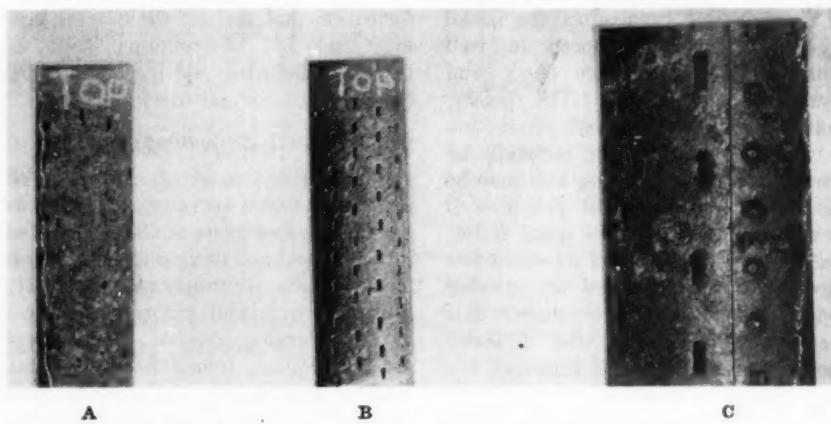
the well. Costs have frequently exceeded \$2,000 per well.

### Incrustation

Incrustation in wells is the most prevalent cause of production loss (Fig. 1). It is generally described as any clogging or stoppage of the perforated area of a well casing, including the interstices of the adjacent water-bearing formation. The crust takes the form of a hard, brittle, cement-like

2. Incrustation due to the physical deposition of such materials as clays, silts, mica, and alluvium carried to the casing in suspension in the water. These are generally classed as fines and seal off a well as thoroughly as do the chemical deposits.

3. Stoppage due to growth of iron bacteria in the formation adjacent to the well, because the water carries iron or manganese in solution. This condition has been difficult to combat in



**Fig. 1. Effect of Vibratory Explosives on Outside of Heavily Encrusted Casing**  
*View A shows casing segment before vibration; perforations are plugged, and flow condition is very poor. View B shows segment after vibration, with perforations completely cleared and flow condition excellent. View C is a close-up showing clean seam and casing segment; it also shows craters around rivet holes.*

accretion due to the usual chemical deposition of hard, carbonated waters. This accretion eventually develops into a small, irregular mound which completely seals an opening (Fig. 2A).

The causes of incrustation in order of their occurrence are:

1. Incrustation due to chemical precipitation of such materials as sulfates and carbonates carried in solution to the well casing by the water that is pumped.

in the past, as the bacteriological growths are deeply embedded in the voids of the formation and are beyond access.

That all ground water contains incrusting materials can be confirmed by observing the area surrounding a slight leak. It will usually be coated with a whitish substance which is largely calcium carbonate. Precipitation of the material carried in solution to the well casing causes 90 per cent of incrustation. The chief incrusting agent is

calcium carbonate, which serves to cement the particles of the formation together and make the actual deposits, or impervious seal, at the perforated area.

The accepted theory of the accelerated formation of incrustation at the perforated area is based on the knowledge that all ground water contains free carbon dioxide gas that was absorbed when the water fell as rain, snow, or sleet. Water will absorb more carbon dioxide when the temperature is reduced and pressure in-

The chemical balance of the ground water is upset by changes in temperature, pressure, and flow rate induced by pumping. Gases are emitted and mineral salts, with extraneous matter, are deposited. Incrustation starts, therefore, when pumping is commenced, as the pressure in the area is reduced by the difference between static and pumping levels—the drawdown. This action accounts for the heavy deposit at the edge of perforations shown in Fig. 2A and gives sub-

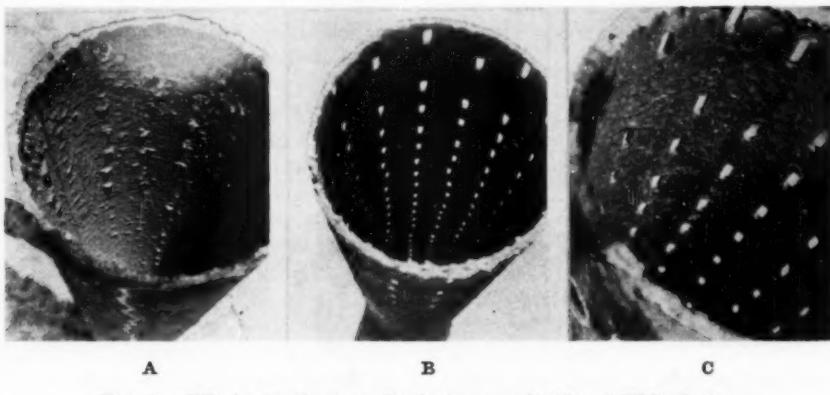


Fig. 2. Effect of Vibratory Explosives on Inside of Well Casing

*View A shows casing interior before vibration, with nodular accretions blocking perforations. View B shows clearing of perforations effected by explosion. View C is a closeup to indicate thoroughness of cleaning.*

creased. More pronounced effects may be expected, therefore, in the deeper, cooler wells.

The carbon dioxide gas and the water form a mild carbonic acid which is sufficiently active to dissolve limestone by the formation of soluble bicarbonates and other elements in the path through the subsurface formations. These mineral salts, gases, and extraneous matter are precipitated or released in accordance with definite physical and chemical laws.

stance to the old recommendation that, when incrustation is expected, the production rate should be decreased to reduce the precipitation of solids. This remedy, in the face of declining water tables and increased water requirements, is unpopular and is seldom observed.

#### Early Experiment and Development

A method of removing incrustation and thereby increasing the production of a well without endangering its struc-

ture was the aim of several practical water works engineers. A starting point was derived from the oil industry, which had used explosives for the initial development and for redevelopment of oil wells for many years. Investigation also revealed that explosives had been used quite extensively in southern California for redevelopment of water wells. The practice was called "shooting a well" but was strictly a hit-or-miss proposition, as no records of benefits had been kept. Explosives

aged that further use of the product was discouraged. Some casings were cut at the fluid level, others split longitudinally, and one was torn at regular intervals (1).

The benefits obtained were most promising, but the hazards were too great. The magnitude of the explosion obviously had to be reduced and sustained for a longer period of time to avoid damage while producing maximum cleaning action. Because this field was entirely new, powder com-

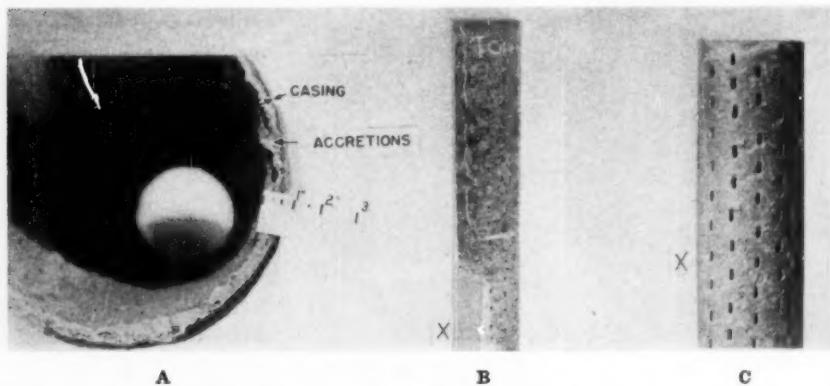


Fig. 3. Effect of Vibratory Explosives on Heavily Encrusted and Artificially Plugged Casing

*View A shows heavy accretions on casing wall. View B shows exterior surface before vibration, with concrete patch clearly visible. View C indicates results of vibration: perforations cleared and concrete patch removed.*

used varied from No. 6 electric detonating caps to Primacord.\* Further investigations disclosed that a well servicing firm had, on several occasions used Primacord successfully to improve production.

Under supervised tests, thirteen wells were shot with Primacord. Two of the wells were damaged, and, subsequently, others were so seriously dam-

pany engineers and well drilling men were unable to offer assistance. Two of the foremost consultants in explosives were engaged, and field tests were conducted on actual samples of casing that were lowered into an abandoned well. Fundamental formulas for maximum pressure created by an explosive and bursting strength of various steel tubes were confirmed. The use of a proper safety factor between these forces made it necessary only to obtain explosives suitably graded down in en-

\*A cord containing an explosive, manufactured by Ensign-Bickford Co., Simsbury, Conn.

ergy, properly spaced, and detonated at proper time intervals. To accomplish these objectives, vibratory explosives were created.

### Vibratory Explosives

The vibratory explosives method was tested under actual operating conditions and showed such promise that patent claims were immediately filed.\* Actual work using this process is being handled by licensees. The minimum Primacord charge currently obtainable is 30 grains per ft, with a detonation rate of approximately 20,350 fps. Computations show that the equivalent energy of 30-grain Primacord is approximately 300,000 hp. Although Primacord has been successfully used in oil wells with small-diameter, thick-walled casing, it has often caused failure of thin-walled well casing used in relatively low-pressure water wells.

The vibratory method enables extension of the beneficial effect for a period that is more than 5,000 times as long as that for Primacord, and it also facilitates the compounding of explosives that are only one-ninth as powerful as Primacord. If desired, the rate of energy delivery can thus be reduced to  $\frac{1}{45,000}$  of the Primacord delivery rate without any reduction in total energy used. In this factor lies the safety of the method.

### Bubble Cycle

The effect of the large quantities of gas generated by underwater explosions has been carefully studied and recently was released from security restrictions (2).

High speed photography and fast recording gages have revealed that the gas bubble forces the water to move away so rapidly that an afterflow, or

enlargement of the bubble beyond its normal capacity, is produced. This overinflated-bubble condition is easily overcome by the hydrostatic pressure surrounding it—again at a rapid rate—and the bubble contracts. The cycle then repeats itself with diminished energy. Approximately ten cycles are completed before the energy is substantially exhausted. As the bubble is confined within a well casing, it can escape only through the openings or perforations. This action produces a thorough washing of the incrusting materials which are vibrated loose by the use of the shock wave of the explosion.

### Use of Vibratory Explosives

The perfected method of employing vibratory explosives involves the use of special explosives that are spaced on various leads to correspond with the perforated area. This prepared firing string is introduced inside the well casing while the pump is still installed. To facilitate access, it is necessary only to suspend the pump assembly 3 or 4 ft above the well.

After the firing line is in position, with the explosives opposite the perforated area, the charges are detonated at predetermined intervals by a special firing mechanism. The explosions produce a continuous series of shock waves of relatively long duration that may be used safely in various casings, yet are powerful enough to shatter and dislodge obstructions in the perforations or in the interstices of the surrounding formation.

The gas bubble expands and contracts approximately ten times after each explosion, so that the water is forced out through the perforations and back into the well ten times for each charge. After this cycle is completed, the second series of explosions is set off, and so on until the entire chain is

\* Patent applied for by Norman A. McLeod, Altadena, Calif.

used. Thus, carefully calculated charges of sufficient force to dislodge or break up incrustation and wash it free in one simple operation may be used without removing the pump.

### Effectiveness of Technique

Actual specimens, shown in Fig. 1 and 2, were in service 15 yr and were accidentally removed from a well while it was being serviced show the

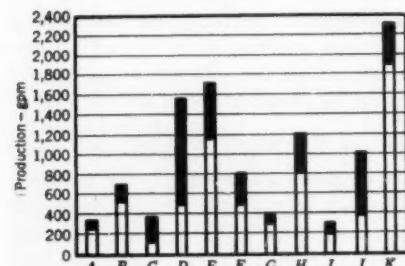


Fig. 4. Effect of Vibratory Explosives on Production

The white portions of the bars show production before treatment; the black portions show improvement with present pump.

KEY LETTER	WELL NO.	YEAR DRILLED
A	Hampshire 12	1925
B	Adelaide 1	1926
C	C. J. Dailey 60A	1930
D	Barstow 2	1930
E	Colton 13	1934
F	American Sugar 5A	1935
G	Normandie 2	1935
H	Walnut Park 9	1947
I	McVine 1	1948
J	Beaumont 4A	1949
K	Whittier 12	1951

effectiveness of the vibratory explosive method. Much of the incrustation on these specimens was jarred loose and wiped off while the casing was being pulled through the formation. An oversized bailer was stuck in the transition section at the top of the string of machine-slotted casing. Jars and walking beams were used with such force that the rivets popped in some sections, and the casing was actually pulled from the well. This rough treat-

ment left only the most secure incrustation, which is shown in Fig. 1A and 2A.

As the specimen shown in Fig. 1 and 2 was only 6 ft long, it was lowered into an abandoned well, and only two-thirds of a normal charge was suspended inside. The purpose was to increase the intensity of the explo-

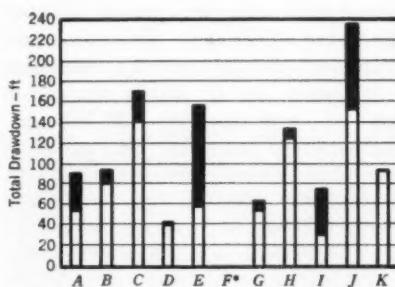


Fig. 5. Effect of Vibratory Explosives on Drawdown

Each bar represents drawdown before use of vibratory explosives. Black portions of bars represent reductions effected by their use. Drawdown in Well D was maintained nearly constant by discharging to waste. Well K was test pumped at constant drawdown.

KEY LETTER	WELL NO.	YEAR DRILLED
A	Hampshire 12	1925
B	Adelaide 1	1926
C	C. J. Dailey 60A	1927
D	Barstow 2	1930
E	Colton 13	1934
F	American Sugar 5A	1935
G	Normandie 2	1935
H	Walnut Park 9	1947
I	McVine 1	1948
J	Beaumont 4A	1949
K	Whittier 12	1951

\* Drawdown unobtainable because of airlift.

sion gradually until complete cleaning was achieved. Contrary to expectations, the first series produced the desired results, as shown in Fig. 1B, 1C, 2B, and 2C.

To study the effectiveness of vibratory explosives further, a concrete patch approximately  $\frac{1}{4}$  in. thick was securely troweled on the inside, and

another of the same thickness was placed on the outside of the casing (Fig. 3A and 3B). The concrete was a hand mix of one part Portland cement and two parts plasterer's sand, and was allowed to set two days. It was subjected to the same two-thirds charge and was thoroughly dislodged and carried away, as is indicated in Fig. 3C.

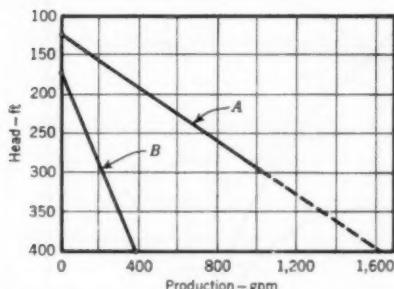


Fig. 6. Improvement in Production of Individual Well

The well tested was Beaumont Irrigation Dist. Well 4A. Curve A represents drawdown after use of vibratory explosives, and Curve B represents drawdown before their use. Solid portion of Curve A shows actual increase achieved with present pump, and broken portion indicates potential increase requiring larger pump. Specific yield increased from 1.61 gpm per ft of drawdown before use of vibratory explosives to 6.55 gpm per ft of drawdown after their use.

The rivets of this section were badly corroded. A full section was so badly weakened that severe jarring by the service rig carried it entirely away. The enlarged view in Fig. 1C reveals craters around these rivets on the outside row. Many of them were completely ineffective on the inside row. Vibratory explosives that were so effective in removing the incrustations and concrete patches did not shear one rivet on the 6-ft test specimen.

A powerful charge of explosives is not required for effective cleansing of well perforations. The sustained vibration accompanied by a washing action by the bubble-cycle is most effective. The following analogy is offered as an illustration: to remove scale from a thin-walled pipe, a machinist's hammer and repeated blows, instead of a single blow from a sledge-hammer, would be used.

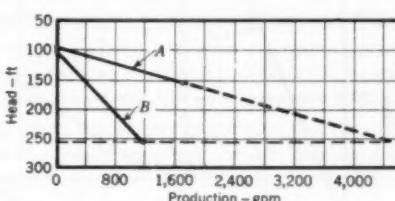


Fig. 7. Improvement in Production of Colton Well 13

Curve A represents drawdown after use of vibratory explosives, and Curve B represents drawdown before their use. Solid portion of Curve A shows actual increase achieved with present pump, and broken segment indicates potential increase possible with larger pump. Specific yields were: before treatment (June 21, 1950), 7.4 gpm per ft of drawdown; after treatment (June 26, 1950), 28.9 gpm per ft; after continuous operation for 1 yr 4 months, 32.5 gpm per ft of drawdown (Oct. 8, 1951).

Vibratory explosives are currently being used with great success to improve wells by: [1] redevelopment, [2] development, and [3] removal of growths.

#### Redevelopment

The original objective of the vibratory explosive method was redevelopment of sick wells by removing incrustation or fines at perforated areas. This use is still the most popular, and its benefits have proved spectacular.

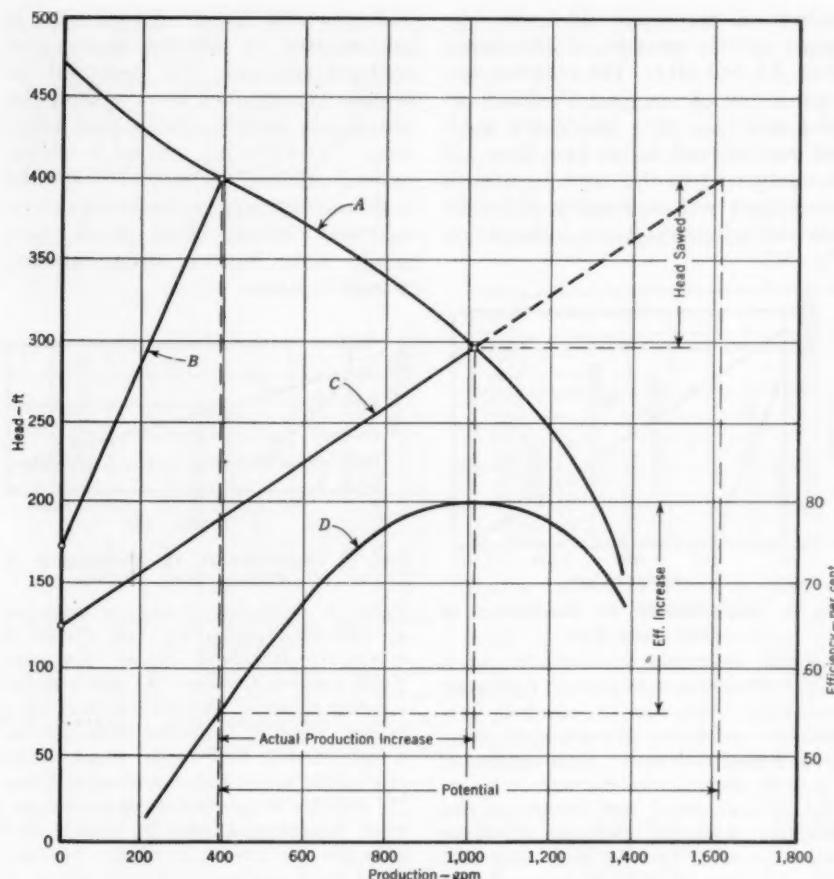


Fig. 8. Effect of Well Improvement on Pump Operation

Curve A represents head capacity; Curve B, drawdown before treatment with vibratory explosives; Curve C, after treatment; and Curve D, efficiency. The specific yields were 1.61 gpm per ft of drawdown and 6.55 gpm per ft, respectively, before and after treatment. Head saved was 103 ft. Efficiency increased 25 points or 45 per cent. Production increases were: actual, 632 gpm; and potential 1,232 gpm. The well tested was Beaumont 4A.

A summary of the benefits to eleven wells located in southern California are shown graphically in Fig. 4 and 5. The dates following the well names and numbers represent the dates drilled. This study includes a new well and others as much as 26 yr old. The

black caps on the bars in Fig. 4 represent the improvement in production obtained by the use of vibratory explosives, and the caps in Fig. 5 show the decrease in drawdown.

The improvements in production and drawdown for Beaumont Well 4A

and Colton Well 13 are shown in Fig. 6 and 7, respectively.

Specific yield which is the yardstick of productivity, is measured in gallons per minute per foot of drawdown, and is affected both by increased production and decreased drawdown. Beaumont Well 4A showed an improvement of 326 per cent. The specific yield graph superimposed on the head capacity curve of the pump reveals the

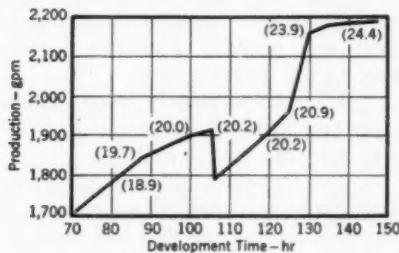


Fig. 9. Effect of Vibratory Explosives on Development of New Well

The well charted is Whittier No. 12. All pumping rates are corrected to 100-ft pumping level. First upward slope of the production curve to slightly more than 1,900 gpm represents development with normal methods. Vibratory explosives were introduced on Feb. 13, 1951. Production decreased to slightly less than 1,800 gpm and then increased rapidly to 2,190 gpm. Second upswing of production curve represents development after use of vibratory explosives. Figures in parentheses represent specific yields.

improvement of pump efficiency with the consequent power saving (Fig. 8).

These studies suggest that the use of vibratory explosives improves the well and permits the pump to operate near designed efficiency. Statistics are even more impressive. The average improvement for all the wells in Fig. 4—with the exception of the new well, in Whittier No. 12—was 158 per cent. A retest of Colton Well 13 shown in

Fig. 7, revealed a gain of an additional 23 per cent after continuous operation for one year and four months. This continued improvement has been recorded on four occasions in different wells.

### Development

It naturally follows that, if the use of vibratory explosives is helpful in re-development, it might assist in developing wells that are impeded by tight formation and are slow in giving up their water. Three wells in a proved area and adjacent to good producers were treated with vibratory explosives. Two of them had been in service for two or three years but had never been completely developed. The results on both were excellent.

The third, Whittier No. 12, was completely developed by the usual methods but did not produce a specific yield comparable with that of neighboring wells. A part of the development of this well is charted in Fig. 9.

A test pump with a variable-speed gasoline-engine drive was installed during the development period. This feature maintained a pumping level of approximately 100 ft. Variations were corrected so that production per unit of time might be plotted on a single graph. Figure 9 indicates that conventional development methods produced a very low specific yield for the vicinity and showed slow improvement. Vibratory explosives were used and the well temporarily lost 100 gpm of production because of rearrangement of the aquifer, but they opened new passages and raised the capacity from 1,920 gpm to 2,190.

Vibratory explosives may be credited with an additional yield from this well that would have otherwise not been available. Convenience and economy in using vibratory explosives make it

appear that their earlier employment might have produced better results than the time-consuming conventional methods which had been used. The use of vibratory explosives on new wells has certainly proved its worth and may well be adopted by any well driller for stubborn wells.

### Removal of Growth

The discharge water of many wells treated by vibratory explosives for removal of incrustation contained, in addition to large quantities of the incrusting material, dead and living growth in masses ranging from small particles to large sheets.

One well was recently observed to have a thick coating of gray and black growth on the inside of the discharge pipe. This growth had the consistency of custard and was covered with a thin, irregular layer of a leathery black substance, the identity of which was not determined. The growth was permeating the system, affecting the operation of meters, and annoying the customers. The production of the well was also seriously curtailed. The incrustation had presumably been removed only two years before, first by 30-grain and then 50-grain Primacord. Vibratory explosives were used with excellent results, and production was actually increased from 790 to 1,250 gpm.

### Conclusions

Much is still to be learned of vibratory explosives. Their use is limited only to wells that show particular symptoms, but a new tool has apparently been introduced to assist the hard-pressed water utility and the well driller who desires to obtain more water from a stubborn well. Not only have the old aquifers been activated, but new ones may possibly have been

brought into use, as has often been confirmed by taking water samples before and after vibratory explosive treatment. Laboratory analyses showed marked differences in the characteristics of the waters.

The following facts are well established:

1. Water wells can be improved safely by the use of explosives.
2. Explosives, if properly used, are the least expensive well restoration method, require the shortest shutdown time, and produce minimum disturbance to the pumping unit.
3. If indiscriminately used, explosives are definitely hazardous to property, and can ruin a well.
4. For the water industry, the vibratory explosives method appears to be the most useful one that has been developed. It is safe because explosives follow definite laws, and formulas have been developed to calculate the explosive force which can be applied to the function desired. The method is effective: small changes, accurately timed, clean the casing and surrounding formations. It is convenient: small multiple charges can be detonated anywhere within the casing, thus leaving the pump practically undisturbed. The method, finally, is thorough: complete cleaning is achieved by the sustained vibration. By combining small charges, accurately spaced and carefully timed to use the secondary effect of colliding shock waves and the ten washings of the bubble cycle, the equivalent energy of high explosives can be used safely in water wells.

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# Stability and Activity of Activated Silica Sols

By Clarence R. Henry

*A contribution to the Journal by Clarence R. Henry, Chief Chemist, Miami Dept. of Water and Sewers, Hialeah, Fla.*

THE so-called "activated silica" used in water treatment as a coagulant or coagulant aid is a weak silica sol that may be produced in a variety of ways. As originally developed by Baylis (1) in 1936, a 1.5 per cent  $\text{SiO}_2$  solution of sodium silicate is partially neutralized by dilute sulfuric acid. This end may also be effected by other acids or acid-forming substances, such as hydrochloric acid, chlorine gas, or carbon dioxide gas.\* Partial neutralization with another coagulant—alum—is achieved by Baker and Dedrick,† whereas, in the Graf-Schworm method ‡ (2), the alkalinity is completely neutralized and excess acidity may be found. Generally speaking, all of these methods, by reducing the alkalinity, weaken the power of the strongly alkaline sodium hydroxide to hold silica in solution. The solution becomes unstable; micelles form and increase in size until a viscous liquid is formed. They may continue to enlarge until a solid gel results. Yet an active sol may be produced by ammonium sulfate with little reduction in pH, and the production of sols from such seemingly unlikely agents as sodium chromate, aluminate, and metaphosphate § is reported by Merrill (3).

\* U.S. Patent 2,217,466, assigned Oct. 8, 1940, to John R. Baylis.

† U.S. Patent 2,310,009, assigned Feb. 2, 1943, to C. L. Baker and C. H. Dedrick.

‡ U. S. Patent 2,234,285, assigned Mar. 11, 1941, to A. V. Graf and W. B. Schworm.

§ A product of Calgon, Inc., Pittsburgh.

The interest in these sols and their application to water treatment stems from their efficiency in the clarification of water before filtration. In the clarification of turbid waters, a coagulant is applied to hasten settlement. A highly colored, soft water will be treated with alum at a low pH to form a "color floc." In lime softening, an aluminum or iron salt may be added to increase the particle size of the calcium carbonate that is formed. After slow mixing for floc conditioning, settling is encouraged in large basins, or in the zones of the solids-contact type of reactor, before filtration. Coagulant efficiency will determine the design and operating size of the equipment. In this aspect the silica sols have proved valuable in improving coagulant action with the aluminum and iron salts previously and customarily used (4, 5). In lime softening, a silica sol alone will sometimes produce an excellent floc when no practicable amount of the other coagulants will produce any floc (6).

The original and usual recommendations for the preparation of a sol by means of sulfuric acid are: A solution of sodium silicate is prepared which will have a 1.5 per cent  $\text{SiO}_2$  concentration after partial neutralization with dilute sulfuric acid to give a total alkalinity as calcium carbonate of 1,200  $\pm$  50 ppm. After the solution has aged for 1-2 hr, it is diluted to 0.6 per cent  $\text{SiO}_2$  concentration—or less—to prevent gelation.

### General Considerations

Inherent in the recommended method of preparation itself is the danger of preparing a sol that gels before dilution. There is also the possibility of preparing a poorly activated sol, thereby losing a portion of its value. The result of slight carelessness or of unavoidable delay in the preparation of a sol may be a gel that produces a cleanout and disposal problem.

Filter plugging has been observed by some operators, and is variously ascribed to the use of insufficiently diluted acid or to poor mixing during the preparation of the sol. Poor mixing would permit local areas of overneutralization and produce some gelled material within the sol. Insufficient backwash rates in filter washing are said to allow the heavier silica floc to remain on top of the filter sand. Proper or sufficient neutralization is emphasized by others, who say that the sols which are more alkaline produce a jelly-like, sticky floc which coats the filter sand (7).

Available statements on the activity of the sols are very general. The proper dosage should be determined by laboratory experiment, using the jar test for comparative, experimental water treatment studies. Most reported work has been performed using comparatively cold water, and the efficiency of a sol has been observed, if at all, only qualitatively, as the measurement of time necessary for the formation of a distinct floc (1).

### Experimental Work

Sols were prepared in the laboratory, and their action as a coagulant in lime softening was measured. The average temperature was 29°C. The water used—taken from the Miami

Canal—requires a coagulant. A small dosage of silica is sufficient to coagulate, although no amount of alum up to 154 ppm will produce a floc (6). A typical average analysis of this water is given in Table 1.

Although the size of the floc particles varied, they were formed almost simultaneously for all dosages. The particles were tough and heavy, and settled rapidly, forming a pile under

TABLE 1  
*Typical Analysis of Miami Canal Water*

Characteristic	Amount
	ppm
Color	100-120
Free CO <sub>2</sub>	25
Total Dissolved Solids	360
Turbidity	0
Silica (SiO <sub>2</sub> )	7.8
Total Iron (Fe)	0
Calcium (Ca)	91
Magnesium (Mg)	7.8
Sodium and Potassium (Na)	7.7
Alkalinity (CaCO <sub>3</sub> )	
OH	0
CO <sub>3</sub>	0
HCO <sub>3</sub>	230
Sulfates (SO <sub>4</sub> )	19
Chlorides (Cl)	24
Total Hardness (CaCO <sub>3</sub> )	260
Noncarbonate Hardness (CaCO <sub>3</sub> )	40
pH	7.3
Temperature—C	29

the stirrer, operating at the rapid mixing rates in the jar-test machine. Varying amounts of very fine turbidity—calcium carbonate that had formed in softening without attaining the size necessary for settling—did not settle. As the silica had been thoroughly mixed with the water before the lime was added, the formation of the larger floc particles was due to the silica. The extremely fine particles, however, were

due probably to the lack of the actively charged particles from the sol. Measurement of this residual turbidity was believed possible and from it the activity of the sols could be gaged. Sol's of equal activities would coagulate and allow to settle equal amounts of the calcium carbonate formed in softening. Less active sols, or lesser amounts of actively charged silica particles, would coagulate and allow to settle smaller amounts of calcium carbonate, and larger, measurable, quantities of fine turbidity would thus be left in suspension.

#### *Preparation of Silica Sols*

The sodium silicate used was purchased on the open market. Its chemical composition is given in Table 2. This is the type recommended as furnishing the cheapest silica. A stock solution containing 20.000 g of  $\text{SiO}_2$  per 100 ml was prepared by weighing 696.6 g of the sodium silicate into a beaker and washing it into a 1-l volumetric flask with boiled distilled water.

In the preparation of a 1.5 per cent silica sol, 150.0 ml of the stock solution was made up with distilled water to a volume of 1,560 ml in a 2-l beaker, in which it was stirred mechanically at the fastest possible rate to avoid creeping and splashing. Exactly 240.0 ml of 1.000N sulfuric acid was measured by and added from the same volumetric pipets to the vortex formed by the stirrer to produce a total volume of 1,800 ml. From this amount, 200.0 ml was removed and immediately placed in a 12-oz prescription bottle containing the measured quantity of distilled water necessary to bring the final concentration of 1.5 per cent  $\text{SiO}_2$ . The bottle was stoppered and the contents mixed.

This method produced a sol with methyl orange alkalinity of approximately 1,500 ppm as  $\text{CaCO}_3$ . Sol's of lower alkalinity, decreasing in 100-ppm steps, were prepared by successive, calculated additions of the acid to the same beaker. Dilution to the same final concentration was effected by pouring 200.0 ml into the proper amount of distilled water. After the preparation of each sol was completed, the bottle containing it was laid in a tray which was loosely hung from a support. The tray was shaken by hand for 30 min. after the completion of the last sol of the series. Stirring in the beaker was continuous, except when the various portions were being removed. A series of

TABLE 2  
*Composition of Sodium Silicate*

$\text{Na}_2\text{O}$ —per cent	8.9
$\text{SiO}_2$ —per cent	28.7
$\text{Na}_2\text{O}:\text{SiO}_2$	1:3.22
Specific Gravity— $B_4$	41
Weight—lb per gal	11.6

9 sols was usually completed within 17 min.

#### *Measurement of Turbidity*

Turbidity was measured with a Lumetron 450\* photoelectric colorimeter. In this instrument, short-form Nessler tubes graduated at 150-mm cell depth are used. The sample tube is filled to the level desired, placed in the tilting cell holder, and optical density is read directly from the illuminated galvanometer scale. The light passes vertically downward through an adjustable diaphragm, a red B-650 glass color filter, and the sample, before

\* A product of Photovolt Corp., New York, N.Y.

meeting the light-intensity measuring cell.

Turbidity as  $\text{SiO}_2$  is read in parts per million from a calibration curve prepared from measurements of Fuller's earth standards that were made up as directed in *Standard Methods* (8). A series of 6 determinations, allowing for a zero reading against a distilled water blank before and after each two samples, may be completed within 5 min. All turbidity measurements are believed to give valid comparative results. They cannot, of course, mean that the apparent turbidity as ppm  $\text{SiO}_2$  due to uncoagulated calcium carbonate is due to silica. Nor is it believed that the turbidity of the silica sols so measured may represent the amount of any given size of the silica present.

#### Jar Test Conditions

The so-called jar-test machine used in the water treatment laboratories is a multiple stirrer. The one used in these studies was an Omega \* that has six stirrers. The stirrer blades are flat,  $\frac{3}{4} \times 3\frac{1}{2}$  in. and were placed at the lowest point on the stirrer shaft. This gave  $\frac{3}{8}$ -in. clearance from the bottom of the 2-l beakers that were used. A variable-speed pulley furnished speeds of 160, 120, 75, 45, and 30 rpm.

To estimate the activity of the silica sols in the work reported, rigid control of all factors was exercised. The effect of silica as a coagulant is markedly affected by the speed and time of rapid mixing and by the amount of the slower conditioning mixing for floc formation. Temperature variations affect the amount of fine turbidity that is produced. Although a good, rapidly settling floc is formed throughout a wide

\* Product of Omega Machine Co., Providence, R.I.

range of lime treatment, the amount of fine turbidity will be affected so that, for example, successive single additions of lime from a pipet during the time necessary is not satisfactory, nor are approximations of the mixing times. Variation in the amount of lime added is also not permissible.

#### Degree of Lime Treatment

To simplify the expression of the alkalinity resulting from lime treat-

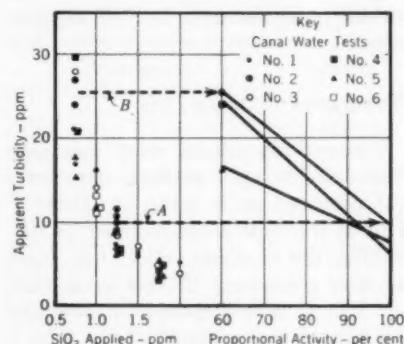


Fig. 1. Jar-Test Effect of Silica

The measurement dosage of 1.25 ppm, which was assumed to represent 100 per cent activity, is shown by Line A. Line B shows the result of a 0.75-ppm dosage—60 per cent activity. Turbidity was noted after 5-min settling.

ment, alkalinity is determined as prescribed in *Standard Methods* (8), and the calculated results, expressed as calcium carbonate, are entered as a three-membered, hyphenated term, in which the first member represents hydroxide, the second carbonate, and the third bicarbonate alkalinities.

Because water containing hydroxide alkalinity from lime treatment contains a lime excess, and the presence of bicarbonate will indicate that it has

obviously received less lime than that necessary to combine with the bicarbonate and carbon dioxide originally present, the two conditions are referred to as "overtreatment" and "undertreatment," respectively. When neither chemical is present, or either is present only in small amounts, the water is "zerotreated." For convenience and simplicity, the degree of lime treatment may thus be described in terms of the amount of hydroxide or bicarbonate alkalinity present. For example, a lime-softened water containing no hydroxide, 20 ppm carbonate, and 30 ppm bicarbonate may be described as a "minus-30-treatment" water, and, if 25 ppm of hydroxide is present, the expression would be "plus-25-treatment."

#### *Measurement of Activity of Silica Sols*

The sols were diluted to 0.2 per cent  $\text{SiO}_2$  concentration for 5 min before use to obtain a working solution. Stirring was begun at 160 rpm. The silica was added successively to the beakers of water. Within a period of 11 sec, starting 20 sec after the last silica addition, separate portions of lime slurry, previously measured into 50-ml beakers, were rapidly added, two at a time, rinsing in and out of the beaker twice.

The stop watch was started with the first lime addition. The drive belt was shifted at 55 sec to 120-rpm and, at 6 min, to 45-rpm conditioning speed. At 16 min, the stirring was stopped, and the stirrers were left in place to act as stilling vanes. At 20 min, samples were removed from a depth of 1-in. below the surface of the water, placed directly into the Nessler tubes to give 150-mm cell depth (by means of a 100-mm pipet with the tip cut off and bent through 75-deg U to draw the sample

downward from the top), and the turbidity was immediately determined with the colorimeter. The water was filtered, and alkalinity determinations were made to establish the degree of lime treatment.

Although some variation and lack of reproducibility in resultant turbidity is to be expected at the lower silica dosages because of the degree of lime treatment, reproducibility at silica dosages greater than 60 per cent of the amount required for the production of minimum turbidity may be considered good if lime is added in excess of the minus-5-treatment and excellent in the range of plus-5 to plus-20. For the entire period of the work, the required silica dosage was quite uniform at 1.25 ppm of  $\text{SiO}_2$ . All comparisons were made, nevertheless, on the basis of a duplicate calibration run made on the same day, in which the same batch of water was used with a sol known to be 100 per cent active.

#### **Results**

Figure 1 shows the results obtained from several calibration runs in which the sol used was known to be of maximum activity. The measurement dosage was selected as some increment less than the required dosage for maximum clarification. When sols of unknown activity are measured, this measurement dosage of silica was applied, and the resultant turbidities were measured. The proportion of activity was estimated graphically from a curve prepared the same day. When this curve was prepared, the turbidity obtained from the measurement dosage was assumed to represent 100 per cent activity. The turbidity obtained from some dosage of 60 per cent or more of the amount of applied  $\text{SiO}_2$

was taken as that proportion of activity, and the two points were connected by a straight line. To obtain the proportion of activity, the results of the jar-test activity determinations were taken directly from this relationship.

lower portion shows a continuation of these determinations for 25 days.

No data are presented for stability, as the sols with alkalinites of more than 1,000 ppm did not gel within 40 days. A sol of 900 ppm alkalinity, which attained some incipient gelation

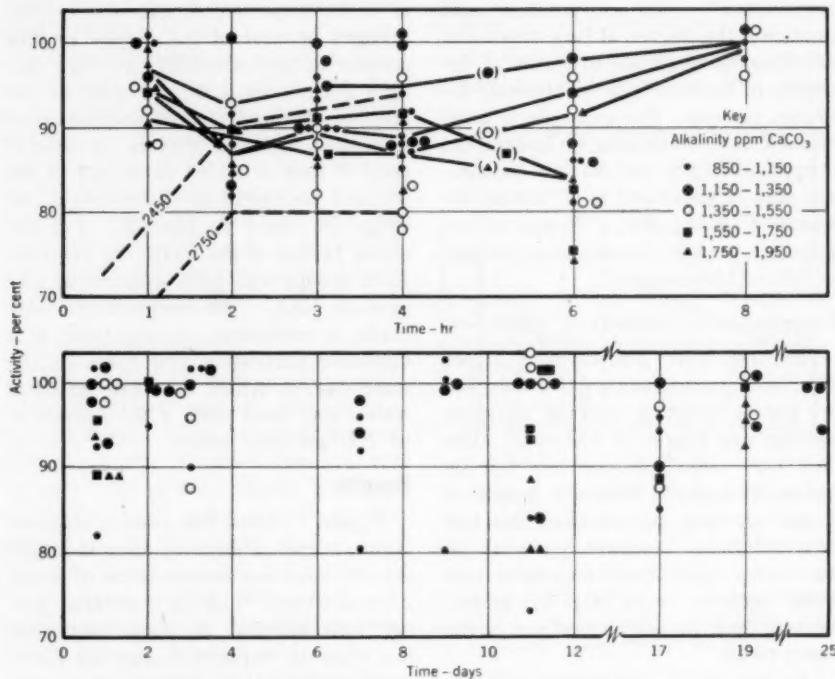


Fig. 2. Activity of 1.5 per cent Silica Sol

Upper portion of figure shows results of estimation of proportional activity for first 8 hr. Lower portion shows continuation of determinations for 25 days.

#### Stability and Activity of Sols

The upper portion of Fig. 2 shows the results of the estimation of proportional activity of 1.5 per cent  $\text{SiO}_2$  sols for the first 8 hr. The various plotted points show the activity of sols of various alkalinites between extremes of 800 and 2,800 ppm as  $\text{CaCO}_3$ . The

in 2.6 hr, was immediately diluted to 1.22 per cent  $\text{SiO}_2$  concentration, and mixed vigorously. In less than 30 min, its viscosity was lost, and small, soft particles were seen when the container was moved. These particles disappeared in another hour, and estimations of activity placed it in line with other sols in the same series. Another sol

of 800 ppm alkalinity, which gelled softly in 0.7 hr, was similarly diluted after an intentional 20-min delay. After the solution was shaken, the gel simply disintegrated into smaller particles, and reformed later as a gel. This action left, after 6 hr, a supernatant liquid layer of approximately 10 per cent of the total volume.

Of further interest is the somewhat erratic behavior of the sols of lower alkalinity; the formation, within a few hours, of sticky rings on the container above the surface of these sols; and the formation of gel in any place of small confinement in thin layers, such as around stoppers and in the tips of pipets. Those low-alkalinity sols that did not gel promptly seemed to attempt gelation and to fail. To protect the final observation, several were noted with time and date as incipient gelation was observed. These notations were found more than a month later on the labels of six or eight quite liquid and active sols.

Figure 3 shows the apparent turbidity at various ages of 1.5 per cent  $\text{SiO}_2$  sols. Development of turbidity, although associated with the activity and with the approach of gelation, is a measure of neither. The active particles are too small to be seen and are certainly not the ones which cause gel formation. The amount of visible turbidity is not at all proportional to the activity, as a sol with an apparent turbidity of 20 ppm would then be five times as active as one with a turbidity of 4. This relationship, however, does not exist. A liquid, stable sol of the lowest alkalinity would appear to contain the greatest quantity of unusable and objectionable material. In conjunction with the other observations, this factor appears further to favor the sols of higher alkalinity.

Figure 2 shows that alkalinites of considerably more than 2,000 ppm might be carried. Alkalinity control may be established at 1,800–2,000 ppm as  $\text{CaCO}_3$  and be assured of more than 90 per cent activity after 4-hr aging.

Plant and laboratory observation will indicate that activity is increased by ample mixing during preparation. In a neighboring plant,\* the necessary dilution of the acid was approximately 1*N* (approximately 9 lb of sulfuric acid in 20 gal), and, unless the acid were added very slowly during a period of approximately 25 min to the vortex formed by the mixing propeller blades, a considerable decrease resulted in activity and in filter runs. This decrease was probably due to a lack of real mixing. Large areas of strong concentration of acid would cause immediate gel formation. This formation would appear as an unnecessary increase in turbidity which was simply filter-plugging material.

Since September 1950, that plant has prepared its sol for use in lime softening with excellent results, leaving 1,600–1,800 ppm alkalinity. Batch preparation, storage, and feed has been at 1.5 per cent  $\text{SiO}_2$  concentration. Several definite increases in filter runs have been observed that, unfortunately, were later obscured by air-binding. These sols were more turbid and, at the lower alkalinites, would gel sooner than those prepared in distilled water in the laboratory. This reaction was undoubtedly due to the calcium in the water.

#### *Comparison of Stirring Effects*

To compare the effect of stirring on short-lived sols, several sols were prepared in the laboratory. Comparisons

\* Private communication from William Sydow, Cons. Engr., North Miami, Fla.

indicated that a 6-hr gel time would be reduced to 4 by 2-hr continuous mixing. The addition of approximately 5 g of well washed, fine silica sand to 200 ml of sol that was being stirred, in a futile attempt to grow pure quartz crystals, resulted in an additional decrease in sol life to approximately 2 hr.

Laboratory-prepared sols with an alkalinity of as much as 1,300 ppm have given 100 per cent activity within 5 min of preparation. This observation indicates that low-alkalinity sols may be used without activity loss in continuous preparation with immediate feed. Figures 2 and 3 indicate that turbidity, or objectionable filter-plugging material, has not yet been formed. For batch preparation and storage for relatively extended periods, however, much greater alkalinities must be maintained. Activity will develop within a few hours. At the same time, higher alkalinities are necessary to prevent the development of filter-plugging material.

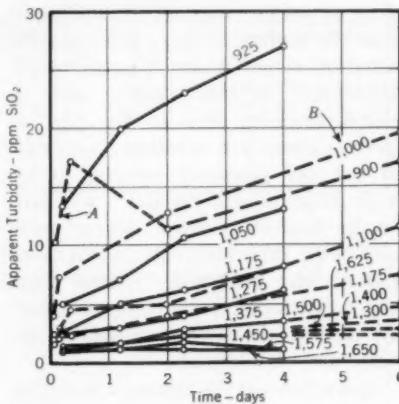
Although the work carefully investigated the properties of silica sols that were prepared with boiled distilled water, plant operation will frequently involve the use of water containing calcium. This condition permits the formation of calcium or calcium-sodium silicates, which shorten the gel time and increase the turbidity beyond the amounts expected from the distilled water preparations. In those waters, ion-exchange softening is recommended in batch preparation.

The observations made of the 1.5 per cent  $\text{SiO}_2$  sols may be applied to those which contain much more than 3 per cent silica. As the  $\text{SiO}_2$  concentration is increased, alkalinity control becomes less critical. This factor, therefore, permits an enormous increase in plant size without a corresponding

increase in the size of batch equipment devoted to sol preparation. With the same size plant, batch preparation will be necessary less than one-third as often. Fear of difficulties from gelation is removed entirely, and filter plugging is minimized.

### Summary

1. A method for estimating the activity of a silica sol is presented.



**Fig. 3. Apparent Turbidity of  $\text{SiO}_2$  Sols**  
Solid lines represent 30-50-min mixing during preparation, and broken lines represent minimum mixing. Numerals represent alkalinity in ppm  $\text{CaCO}_3$ . Point A shows that incipient gelation was noted after 2.6 hr and was diluted to 1.22 per cent  $\text{SiO}_2$ .

2. The stability and activity of silica sols prepared by the neutralization by sulfuric acid of sodium silicate has been observed and measured. Particular emphasis has been placed on the sols which contain 1.5 per cent  $\text{SiO}_2$ .

3. A 1.5 per cent  $\text{SiO}_2$  sol may be prepared at an alkalinity of 1,800-2,000 ppm  $\text{CaCO}_3$  and stored, without fear of gelation, for more than a month. Prompt slight dilutions will effectively

delay gelation and will also actually restore activity to those sols exhibiting incipient gelation.

4. Excessive dilution, to 0.2 per cent  $\text{SiO}_2$  will not, within five days, decrease the activity of low-alkalinity sols. If a sol of 1,800-ppm alkalinity is so diluted, the activity may be decreased 15 per cent during the same period of time.

5. Continuous mixing during the preparation will increase turbidity of a sol. Little or no effect of this sort on the sols of higher alkalinity is noted, but additional mixing will hasten the development of activity.

6. The turbidity observed in the sols as generally prepared is associated with activity and the approach of gelation but is a measure of neither.

7. Sols having a total alkalinity of 1,300 ppm or less attain their maximum activity in less than 5 min and are suitable for continuous preparation with immediate feed.

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## Valve Maintenance and Repair Program at Peterborough, Ont.

By Ross L. Dobbin

*A contribution to the Journal by Ross L. Dobbin, Gen. Mgr., Utilities Commission, Peterborough, Ont.*

FROM 1940 to 1950, Peterborough's water works valves received very little maintenance, first, because of the wartime manpower shortage and, second, because of the heavy new-construction program undertaken. In the summer of 1950, despite heavy commitments for new construction, a repair crew was organized and permitted to operate independent of normal water works duties. The need for an independent unit is essential and should be stressed in such a program, as little hope of completing such a tedious job exists if the men are required to perform other work as well.

The original crew—one which was carried throughout the whole program—consisted of: one foreman to drive the truck, take notes, and record work; one hydrant operator to operate hydrants during tests and help in repairs; two valve operators to open and close valves as required and to make necessary repairs; and two laborers to perform all major excavations. The crew was supplied with a  $\frac{3}{4}$ -ton express body truck which was equipped with necessary valve keys and tools.

For scheduling the program, the city was divided into six convenient areas, each containing approximately 200 valves. Each area was checked separately, and all work within it was completed before work was begun in the next. The possibility of failure to per-

form necessary repair work was thus reduced.

### Typical Test

Area tests were initiated by the foreman, who outlined the locale of the test on a block plan of the city mains. The necessary valve-record cards were assembled and placed in a convenient carrying case. The foreman took the three-man testing crew to the test area and, from one side of it, worked across the entire section, checking the operation of every valve. As each valve was operated, the necessary data on number of turns and, if possible, the manufacturer were recorded. To ascertain that all valves closed fully and to verify the position of all valves (either open or closed), an area was shut off, and a hydrant within it was checked to determine whether the valves were holding. A convenient area required from three to six valves to shut it down. A smaller area was inadequate, and a larger one entailed an involved procedure.

As the valves were checked and necessary repairs indicated, the two diggers were assigned their tasks and as soon as they bared a valve for repairs, the survey crew stopped testing and returned to do the necessary repair work. Thus, the survey crew usually finished an area before all repairs were made. To keep the work together, the hydrant

valves and private service valves of more than 2-in. diam were checked after the main valves. At the same time, the hydrants were packed and greased.

No warning was given to private consumers during the test, as service was interrupted only for a short time. Factories were not cut off unless they were on dead ends and suitable test schedules had been arranged before the tests.

One complaint arose because of a collapsed copper water storage tank, but this tank returned to shape when water pressure was restored.

## Repairs

In order of frequency, faults in the valves occurred because of: [1] faulty packing, [2] plugged valve posts [boxes], [3] broken or damaged spindles [stems], and [4] miscellaneous reasons.

### Faulty Packing

Faulty packing resulted in: hardening and seizing the spindle; hardening and not sealing the spindle; or disintegrating and, after several operations, washing out of the gland.

Several types of packing were encountered. Tallowed hemp sometimes failed because it dried and permitted the water to pass through. Shot packing failed by seizing the spindle, which made operation difficult.

All new packing used was stranded, tallowed hemp that was lubricated with graphite and oil. Every excavated valve was repacked whether it was necessary to do so or not.

### Plugged Valve Posts

Whereas some posts were plugged only by earth, many of them were filled

with stones or pushed off the valve so that a key would not operate them. Earth-filled posts were flushed with a flush pipe. A 1-in. water stream was used to wash out the post and then a water ejector used to remove the water thereby making inspection possible. Stone-filled posts were dug up and reset.

The city works department's power graders, used in shaping its roads, pushed many valve posts off their valves. These posts were excavated and replaced.

In posts in new developments a wood plug with a lifting handle was inserted. This device rests on top of the lower section of the box within hand-digging distance of the surface.

### Broken or Damaged Valves

Of the 1,100 valves checked, only 55 were broken or damaged, and of these, 50 had bent spindles. Spindles that were slightly bent could be removed and changed without shutting off the water. Badly bent spindles necessitated disassembly of the valve and both the spindle and the nut were changed. Serious bends generally stripped the spindle nut threads.

Each time a valve was taken apart, new gland bolts were used. They were usually badly corroded, and time would have been wasted in saving them. New gaskets and packing were always installed, and the insides of the valves were cleaned with a wire brush and chisel.

With water turned off and five men on the job, a 6- or 8-in. valve could be disassembled in approximately 30 min. All but four bolts were removed from the bonnet while the water pressure was still on; the water was then turned off, and the balance of the bolts removed. Two men cleaned the gates on the bank, one man cleaned

the body, and two more cut gaskets for the bonnet and fitted spindle-and-nut and packing-gland assembly. The bonnet assembly was lowered to the man in the ditch, placed in the valve body, and bolted up again.

#### *Miscellaneous Repairs*

In three valves which were repaired, the gland was broken during removal from the stem. Two valves would not close properly because of damaged disk faces and seats. These repairs were not attempted by the survey crew. Several faulty manhole-valve chambers were discovered and were referred to the water department repair staff.

Pavement cuts were a problem. Fortunately, chambers were constructed in most permanent pavements, and only six cuts were required. Most of the roads are of the surface-seal type and are therefore not difficult to penetrate or repair.

#### **General Remarks**

Approximately 30-40 valves could be tested daily by the crew. Repairs consumed most of the time. Toward the end of the job, the foreman accompanied the crew when testing, but

stayed in the shop while the repairs were conducted.

Records included a card index of each valve which showed location, particulars, date of operation, and condition. A log book was also kept to note the valves tested and the necessary repairs.

To make certain that all valves were left open, reference was made to the cards which were used. A card which was placed on end in the file indicated a closed valve, and a card in the normal position indicated an open one.

Work was started April 19, 1950, and continued until the end of September. Labor costs were: one foreman, \$1.37 per hr; five laborers at \$1.09 per hr, \$5.45; one truck (less driver), \$2 per hr; total, \$8.82 per hr. The entire labor expenditure for the total of 888 gang-hr was \$7,840. Materials costs were: valve repairs, \$450; 12 yd of pavement cuts at \$5 per yd, \$60; bolts, gaskets, and hemp, \$75. Thus, the total costs were \$8,425, and the unit cost \$7.67 per valve.

The work performed included: 1,098 valves checked, 55 repaired, 153 packed, 111 dug, 29 flushed, and 525 hydrants checked.



## New Journal Abbreviations

**S**TANDARD abbreviations to be used in the JOURNAL have been modified to conform generally with those adopted by American Standards Assn. The principal change has been the dropping of periods, except when such removal would cause ambiguity, as, for example, with the abbreviation for *inch* (*in.*). To conform with this style, periods are also being removed from such abbreviated designations as ASA and AWWA. The new technical abbreviations are:

acre-foot	acre-ft	feet board measure (board feet)	fbm
alternating-current (adj.)	a-c	feet per minute	fpm
ampere (s)	amp	feet per second	fps
ampere-hour (s)	amp-hr	Figure (s)	Fig.
Angstrom unit	A	foot	ft
atomic weight	at.wt	foot-pound (s)	ft-lb
avoirdupois	avdp	free on board	fob
barrel (s)	bbl	gallon (s)	gal
billion gallons	bil gal	gallons per day	gpd
biochemical oxygen demand	BOD	gallons per hour	gph
board feet (feet board measure)	fbm	gallons per minute	gpm
brake horsepower	bhp	gallons per second	gps
brilliant green bile broth	BGB	grains per gallon	(convert to ppm)
British thermal unit	Btu	gram (s)	g
bushel (s)	bu	hectare (s)	ha
centigram (s)	cg	hogshead (s)	hhd
centiliter (s)	cl	horsepower	hp
centimeter (s)	cm	horsepower-hour (s)	hp-hr
chemically pure	cp	hour (s)	hr
counter electromotive force	cemf	hundredweight	cwt
cubic	cu	inch (es)	in.
cubic centimeter (s)	ml	inch-pound (s)	in-lb
cubic feet per minute	cfm	inches per second	ips
cubic feet per second	cfs	indicated horsepower	ihp
cubic foot (feet)	cu ft	indicated horsepower-hour (s)	ihp-hr
cubic inch	cu in.	inside diameter	ID
cubic meter (s)	cu m	kilocycles	kc
cubic micron (s)	cu $\mu$	kilogram (s)	kg
cubic millimeter (s)	cu mm	kilograms per second	kgps
cubic yard (s)	cu yd	kiloliter (s)	kl
degree (s)	deg	kilometer (s)	km
degree Centigrade	°C	kilometers per second	kmmps
degree Fahrenheit	°F	kilovolt (s)	kv
direct-current (adj.)	d-c	kilovolt-ampere (s)	kva
dissolved oxygen	DO	kilowatt (s)	kw
dram (s)	dr	kilowatthour (s)	kwhr
electromotive force	emf	linear foot	lin ft
elevation	el	liter (s)	l
eosin methylene blue	EMB	logarithm (comm <sub>n</sub> )	log
Equation	Eq	logarithm (natural)	log <sub>e</sub>
feet	ft	meter (s)	m

microampere (s) .....	$\mu$ a	pennyweight .....	dwt
microinch (es) .....	$\mu$ in.	pound (s) .....	lb
micromicron (s) .....	$\mu\mu$	pounds per square foot .....	psf
micron (s) .....	$\mu$	pounds per square inch .....	psi
microvolt (s) .....	$\mu$ v	pounds per square inch absolute .....	psia
microwatt (s) .....	$\mu$ w	quart (s) .....	qt
miles per hour .....	mph	revolutions per minute .....	rpm
miles per hour per second .....	mphs	revolutions per second .....	rps
milliampere (s) .....	ma	second (s) .....	sec
milligram (s) .....	mg	specific gravity .....	sp gr
milliliter (s) .....	ml	specific heat .....	sp ht
millimeter (s) .....	mm	square .....	sq
millimicron (s) .....	$\mu$ m	square centimeter (s) .....	sq cm
million gallons .....	.mil gal	square foot (feet) .....	sq ft
million gallons per day .....	.mgd	square inch (es) .....	sq in.
millivolt (s) .....	mv	square kilometer (s) .....	sq km
minute (s) .....	min	square meter (s) .....	sq m
molar (concentration) .....	<u>M</u>	square micron (s) .....	sq $\mu$
molecular weight .....	mol wt	square millimeter (s) .....	sq mm
most probable number .....	MPN	United States Pharmacopoeia .....	USP
normal (concentration) .....	<u>N</u>	volt (s) .....	v
Number (s) .....	No.	volt-ampere (s) .....	va
ounce (s) .....	oz	watt (s) .....	w
ounce-foot (feet) .....	oz-ft	watthour (s) .....	whr
ounce-inch (es) .....	oz-in.	week (s) .....	wk
outside diameter .....	OD	yard (s) .....	yd
parts per million .....	ppm	year (s) .....	yr
peck (s) .....	pk		

The most common bacteriological abbreviations used are:

<i>Aerobacter aerogenes</i> .....	<i>Aer. aerogenes</i>	<i>Escherichia coli</i> .....	<i>Esch. coli</i>
<i>Aerobacter cloacae</i> .....	<i>Aer. cloacae</i>	<i>Salmonella typhosa</i> .....	<i>S. typhosa</i>

## Handling Damage Claims

*Carroll C. Clark*

*A paper presented on Oct. 25, 1951, at the California Section Meeting, San Francisco, Calif., by Carroll C. Clark, Claims Adjuster, San Francisco Water Dept., San Francisco, Calif.*

DAMAGE claims arising from the operation of any large water utility are regarded as part of the problem of operation—currently, more than ever before. In recent years the public has developed a trend toward capitalizing on misfortunes. In scanning the news, people find numerous items that publicize damage claims and the liberal judgments awarded by today's juries. People are very alert to the possibilities of obtaining easy money.

An example of this attitude is a recent accident, in which a missing water meter box cover caused a serious personal injury to a minor. The claimant's father, instead of notifying the water department immediately after the accident, called his lawyer. In another case a basement was flooded by a broken water main. The department's investigator surprised the occupant in the act of removing merchandise from upper shelves and dumping it into the water. Fortunately, all claimants are not opportunists.

The San Francisco Water Department finds itself rather vulnerable to claims, as its hundreds of miles of water mains and connecting services are subject to breaks and leaks, and the possibility always exists for the creation of a flood condition. This situation is particularly true for the downtown district, where basements usually serve as storerooms for large quantities

of merchandise. In addition, thousands of meter boxes are installed throughout the city in the sidewalk areas near the curb. Main gate boxes and other appurtenances are also located in the street areas. Many of these devices are actually set in marked pedestrian lanes. Any of these installations may become a hazard if not properly maintained.

It is not necessary to discuss accident prevention and safety, as it is well known that a water utility must always be diligent in keeping its installations in a reasonably safe condition. The San Francisco department is successful in accomplishing this end. Meter readers and other field men have been impressed with the importance of observing and promptly reporting any hazardous conditions at these installations. Meter boxes and surrounding sidewalks are given special attention, thus reducing to a minimum the number of personal injury claims from such defects. Injuries occurring from defective main gate box covers and other appurtenances installed in street areas are comparatively few, probably because pedestrians are more alert when crossing a street.

### **Damage From Breaks**

Breaks in water mains and leaks in services cannot be anticipated—they just happen. A typical break in a wa-

ter main or a leaking service in the downtown area may be discovered when water from the leak starts to seep into a basement through a concrete retaining wall. The tenant or one of his employees notices the seepage and excitement usually follows. By this time, water probably is gushing through the concrete wall, and the basement is being flooded. The occupant finally realizes it is coming from the city system, and the department is called. A gateman is immediately dispatched to diagnose the trouble. If he finds a bad main leak that is causing damage, he will ordinarily shut the main down and call for a main repair crew, whereas, if it is a service leak, he will notify the serviceman who is working nearest to the scene of the leak. He then informs the claims investigator of the occurrence.

The department loses no time, but during the excitement, the claimant forgets to protect his merchandise. The investigator arrives at the scene as soon as possible and advises the claimant to move all the merchandise from the flooded area to prevent further damage. He also asks that all merchandise be removed from any water-soaked cartons or boxes. Experience has proved that if this removal is effected promptly, losses can be minimized.

When repairs are completed and the seepage into the basement is stopped, the department's crew starts to remove the water from the basement. Sawdust is put down to absorb the remaining water, and by the time cleanup operations have been completed, the floor is almost dry. The only remaining evidence of the flood is the water-soaked merchandise.

The investigator then takes a complete inventory with the owner or the

person in charge of the stock. The damaged items are set aside and listed—cost prices are obtained, if at all possible. Invoices substantiating these costs are checked later. It is suggested that the affected articles or goods be set aside for a few days to allow them to dry. The claimant is generally very upset and concerned over his possible losses, and he demands to know what will be done to compensate for them. So that he is not antagonized at this critical time, he is advised that a full investigation will be made, and the department will contact him in a day or so. It is good psychology to let a few days pass before the matter is discussed further. During this waiting period, the investigation is completed, and the department obtains all the data covering its operations at the location of the leak.

### **The Second Call**

By the time the second call is made, the basement is completely dried and the claimant has almost forgotten the flood. Calmness prevails, and the whole picture looks much brighter. The damaged merchandise is rechecked, and the actual loss is usually found not to be so serious as it first appeared. Prompt action in drying the basement and in removing stock from the waterlogged cartons prevented additional damage. Salvage value of losses is discussed, invoices are checked, and the final loss is generally negligible.

The claimant is advised of the proper procedure to follow in making his formal claim against the city. No mention is made of any liability on the department's part. In due time, a claim is received (the San Francisco city charter provides a 60-day time limit for the filing of claims), and if the

claimant is a reasonable person, the claim covers only actual losses. If so, the amount claimed will agree with the department's final inventory, and the losses will be based on actual costs plus any labor charges that may have been incurred.

Such a claimant has been inconvenienced and has suffered damage through no fault of his own. He has given full cooperation during and after the mishap, and his claim for recovery of losses is factual. Most claimants are not covered by insurance for damage caused by a break in a city water main. Some courts have ruled that a water utility is not the insurer of the good condition of its water pipes. The claimant, however, is a consumer—a citizen of the community—who is not asking for exorbitant damages but is merely pleading for reimbursement for out-of-pocket losses incurred by a municipal operation.

The facts are reviewed with the city attorney's office, and it is decided that the claim is reasonable and, if denied, will lead to litigation. Lawsuits are costly, and it is good policy to avoid them if at all possible. It is finally decided to effect a compromise settlement. A month or two is usually allowed to pass before any action is taken on the claim. Sometimes nothing is done until the department hears from the claimant, who is then in a mood to conclude the matter and will usually agree to a satisfactory compromise.

#### Uncooperative Claimants

Not all flood damage cases are readily settled, of course, especially if the claimant, after finding himself involved in an occurrence of this kind, decides an opportunity to profit has presented itself. Nothing can be done at the time

of the flood with this type of person. The department operates in its usual expeditious manner—every effort is made to prevent further damage. The claimant's cooperation is asked, and, if he fails to grant it, his conduct is deemed to be contributory negligence and he is so informed. An uncooperative claimant is usually less interested in salvage efforts than in consulting his lawyer.

One claimant was instructed to remove numerous bolts of denim material from 2-in. floor platforms and to spread the goods out to dry. A check within a few days revealed that he had failed to do so, and the material was badly mildewed. In another drygoods loss, the manager was requested to remove dozen lots of ladies' blouses and other apparel from water-soaked cartons. He did not follow these instructions, because according to him, the labor cost of sorting would be too great.

In another flood, approximately 50 cartons of powdered soap became water-soaked on the bottom. The owner said he would have the individual boxes removed from the cartons but did not do so with the result that water seeped into the cartons and ruined the entire contents.

In a street-level flood, the floor of a commercial aviary was covered with approximately 6 in. of water. The owner of the aviary alleged that the high humidity created by the water caused more than 200 birds to die from pneumonia resulting in a great financial loss. An autopsy on some of the dead birds, which was performed at the department's request, disclosed that the birds had been fed improper seed, and they had actually died of malnutrition.

It is almost impossible to deal reasonably with these people, as claimants are not to be compensated for their own negligence. In such cases, it is best to build a strong defense to prove no negligence by the department and await the turn of events. Threat of legal action is frequently used to intimidate the city, but this coercion is always ignored. If a lawsuit is filed, the pertinent facts are given to the city attorney's office to enable them to answer the suit, and nothing further is done. The department is never in a hurry to deal with this type of claimant.

Eventually the claimant's attorney requests a settlement. The department is always glad to discuss the incident, but maintains its claim of no negligence by municipal employees and continues to deny liability as long as the claimant is unreasonable in his demands. This contention apparently has proved to be a powerful argument, as the city has never been intimidated into an unreasonable settlement. It was hoped that some particularly annoying claims would go to trial, but sensible compromises were readily forthcoming when the opposition realized that the city was determined to defend itself.

### **Structural Damage Claims**

Breaks in mains and services often result in claims for property damage in residential or outlying areas. The hilly topography of San Francisco sometimes causes water from a leak to percolate downhill and to vent up eventually from under the foundation of a building at a lower level. The department, of course, responds promptly to notification of such a condition.

Nearby mains and services are sounded to detect any possible leak. If no sound is picked up, a sample of the

seepage water is placed in a test bottle by the repair crew and is sent to the laboratory for analysis. If the laboratory decides that the seepage is "city water," a leak detector is sent out and the leak is finally located. Necessary repairs are immediately made and any remaining water is removed from the premises.

After making a survey, the property owner will probably discover cracks in the foundation, basement floor, or driveway, and naturally concludes that the cracks are due to subsidence caused by the seepage. Upon notification of this condition, the department immediately dispatches a qualified engineer to make an investigation. During the inspection, which is made in the presence of the owner, the engineer usually finds such evidence as cobwebs, dirt, or grass in the cracks but no evidence of a recent separation of the concrete. All such factors indicate a long-standing condition. Prior to the seepage, the property owner had probably never noticed these cracks and is therefore convinced that they are new and must be a result of the seepage. It is difficult to convince him that the cracks were caused by normal settlement.

One claimant alleged that a main break in the hill above her property caused water to flow against the rear of her home. She claimed this action caused the plaster walls in the rear of the building to become damp, and she filed a large claim for damage. Inspection disclosed that the walls were indeed damp, but a further check showed that the wood-shingle roof was in very poor condition, indicating that rain water seeping through the roof was responsible for the dampness. It was also noted that the house had been built on the north side of a steep hill and was surrounded by tall trees, the heavy foliage

of which had prevented the sun's rays from reaching the rear of the building. This condition also contributed to the dampness. The only cost to the city in denying this claim was to sustain a severe tongue-lashing from the claimant.

In a property damage lawsuit, the testimony of a qualified civil engineer is invaluable. If the claim for structural damage is sufficiently large, it is profitable to engage the services of a disinterested consulting engineer to verify the department's findings. Juries tend to accept such opinions as being without bias.

### Precautionary Measures

Two other phases of operation may result in costly claims for damage. They are: [1] the temporary backfilling of main and service repair ditches and [2] providing water service at the consumer's request.

In San Francisco, every effort is made to keep backfills safe until they can be permanently paved—particularly on heavily traveled streets. Red-rock topping is placed over these ditches and rolled with a truck. Cold asphalt is preferable as a temporary topping. A barricade and red lights or bombs should be placed nearby, out of the way of traffic, as a warning to oncoming vehicles. If a hole or ditch must remain open overnight, the spoil should be placed on the sides with the highest pile facing oncoming traffic. Barricades equipped with reflectors should completely surround the opening. Red lights and bombs should be placed and weighted down on all barricades. These lights should be checked at least once during the night, more often during a weekend. If these precautions are taken and an accident does occur, negligence by the department in pro-

testing the opening in the street will be hard to prove.

Consumers frequently want immediate water service. When a consumers' serviceman arrives at the designated premises to turn on the water, he often finds the place unoccupied. If he does not use due caution, the premises can easily be flooded, especially if a sink stopper is closed and a faucet has inadvertently been left open. The department's men are instructed to be very careful to prevent such an occurrence and to turn on the stopcock only long enough to permit the house piping and fixtures to fill. If the water continues to run through the service and meter, the stopcock is shut off, and a notice is left to advise the consumer that he can have service by turning on the stop cock at the meter.

### Personal Injury Claims

Personal injuries that result from faulty meter box installations or surrounding sidewalks can cause the most costly damage suits. Such accidents do not involve tangible losses that can be substantiated by invoices, but medical expenses, loss of time, services, and those intangibles, pain and shock.

Every effort is made to keep installations in a reasonably safe condition. When a meter reader notices a faulty installation, he notes the type of defect on his field sheet, and, if the condition is a dangerous one, he advises the office by telephone, so that immediate action may be taken. Otherwise, after his reading day is completed, the reader makes out a repair order for each defect found during the day. The next morning these orders are sent to the yard office and are acted on without delay.

If paving is necessary, orders are promptly given to a paving contractor.

Records of these activities are kept on file many years for future reference. The paving contract specifies that an order given to the contractor must be completed by 5:00 PM of the same day, and the contractor must assume full responsibility and hold the department harmless for any injuries or damages that might occur afterwards. This clause has often been a "lifesaver."

### Bimonthly Meter Reading

Just two years ago, bimonthly billing was started. Whereas meter readers had previously read meters each month, they now have the opportunity to check these installations only every 60 days. The courts have held that monthly inspection of these installations was sufficient. When bimonthly billing was inaugurated, the department was prepared for the worst and expected a rise in personal injuries. Meter readers were asked to be especially diligent, and they complied wholeheartedly. Sidewalk meter repair orders increased, but personal injuries did not do so. Paving costs money, but not nearly so much as does the expense of repairing broken bones and making up for lost time.

The department has more than 100,000 sidewalk meter boxes installed near the curb, and the proportion of personal injuries they cause is an absolute minimum. Most of the injuries that do occur involve women, possibly because of their high heels, daydreaming, or just unsureness of foot. As soon as the department is notified of an injury, the installation that is alleged to have caused the fall is inspected, and photographs are taken. Temporary repairs are made if an actual hazard exists, such as a broken or missing meter box cover

or a hole or subsidence in the surrounding sidewalk. If no really dangerous condition is present, no alteration is made. In borderline cases, a repair made after the accident might constitute an admission of fault. While such an allegation is not admissible as evidence in court, the plaintiff's counsel is sure to get it to the jurors' ears before objection can be raised.

### Visit to the Injured Party

The injured person is visited by a representative of the utility. The injured party (who may be assumed to be a woman, and who is definitely a prospective claimant) is naturally upset and suffering some discomfort. She is therefore not in a very receptive mood. She is usually somewhat relieved, however, by having a representative call. Sympathy with and interest in her injuries can gain her confidence. Usually she will already have discussed the accident with members of her family and friends, and retention of a lawyer will have been suggested. By inspiring the injured person's confidence, she may usually be deterred from seeking legal aid—at least until the department has gathered all the facts and can judge the soundness of its case. She is worried about the medical and other expenses and frequently inquires whether it is necessary to engage a lawyer. The department knows that legal counsel will complicate matters and make eventual settlement more difficult, so she is therefore advised that such action is not necessary. The representative is, however, careful to avoid any admission of liability. The injured party is urged not to worry, as everything possible is being done to obtain all the facts regard-

ing the accident. She is also acquainted with the procedure for filing claim against the city.

### Sources of Evidence

Occupants of the premises served by the meter installation that is involved are questioned. Witnesses to the accident, if any, are interviewed and signed statements are obtained if possible. Sometimes these statements tend to incriminate the department, but they should be obtained. One witness who actually saw a claimant trip and fall made an unfavorable statement but retracted it when confronted with a different view offered by another witness. He said the attorney for the claimant, who interviewed him first, had practically put the words of his first statement into his mouth, and he began to believe them. To clear his conscience, he decided to make a truthful statement in the department's favor.

If the injured person is taken to an emergency hospital, the treatment record, condition of the patient, and disposition are copied from the hospital's log. Department records are checked to determine whether, prior to the accident, the defect was ever reported. The meter reader who last read the meter is interviewed and asked to give a statement on the condition of the installation at that time. Other employees who might have had contact with this installation are also questioned. The policeman on the beat, the street cleaner, the mailman, or employees of other utilities who might have been working near the location of the defect are also questioned. They are all asked if they ever noticed the condition of the installation. Their replies have assisted the department establish lack of either actual or constructive notice.

### Settlement of the Claim

The injured person is again visited, and the representative tries to determine how long incapacitation will last and what expenses have been incurred. If the patient is in accord, the attending physician is interviewed. By this time, a fairly clear picture is available. A claim is eventually filed. All data are presented to the city attorney's office and the degree of the city's liability, if any, is determined. If it is decided that the utility has some liability, a maximum compromise settlement is agreed on, and negotiations are then entered into with the claimant. Settlement within this range is generally effected. Litigation of a personal injury suit may result in a costly judgment in favor of the plaintiff, as juries seem to favor an individual in a lawsuit against a utility.

All personal-injury claims, unfortunately, are not handled that easily. Some injured parties have procured legal advice immediately after an accident. The department's inability to discuss the matter directly with the claimant retards any progress towards settlement, and attorneys often insist on unreasonable demands. Sometimes the utility's first notice of an accident is the filing of a lawsuit.

### Importance of Records

Employees have great difficulty in remembering conditions that existed some time previously. The value of keeping full records of all operations, therefore, is easily proved. Records constitute a first line of defense and substantiate the testimony of employees. All efforts must obviously be made when undertaking an investigation of past operations. No stone can be left

unturned when a battle of wits impends. An attorney's defense will be only as good as the facts presented to him. Capable investigations are the keynote in keeping damage claim costs to a minimum. During the past five years, only one personal injury was the subject of a departmental lawsuit, and the decision was rendered in favor of the utility. During the same period, it was not necessary to go to court to decide a single flood damage claim. The total sums of settlements have been amazingly low.

The number of damage claims will be in inverse proportion to the degree of vigilance exercised in keeping installations in safe condition. Prompt response when flood damage is reported is absolutely essential. Delay is inexcusable and strengthens the claimant's legal position in a court action. In handling damage claims, understanding, patience, and tactfulness aid in making satisfactory settlements. The Biblical injunction, "A soft answer turneth away wrath," is still of value.

## New NPA Information

### **Water Meters, Service Line Material, Well Casings**

- Customer-owned water meters or service lines may not, under present NPA regulations, be supplied by the water utility which provides service through them. The customer, himself, or his building contractor must secure these items under a rating granted on some such project as the construction of a home. The water utility is not permitted to extend the U-8 rating to any item of which it does not retain ownership.
- Direction 4 of CMP Regulation 6 (effective as of January 17, 1952) provides a method for securing controlled materials (steel casing, copper wire, etc.) for water wells. For obtaining steel casing, for instance, the new direction provides:

**Steel Casing Required  
per Well**

2 tons or less

From 2 to 6 tons

More than 6 tons

**How Obtained**

Owner self-certification of order

From stock of well driller; no owner rating required

Filing of a CMP-4c form by owner with Water Resources Div., NPA, Washington, D.C.

The well driller's stock of steel casing is based on the amount of casing used in the 2- to 6-ton category during the first half of 1950, the driller receiving his stock on a quarterly basis.

A copy of Direction 4 may be obtained from NPA regional offices.

## Flural—A New Flocculating-Fluoridating Agent

Wayne E. White, Jack C. Gillespie and Otto M. Smith

*A contribution to the Journal by Wayne E. White and Jack C. Gillespie, both of Ozark-Mahoning Co., Tulsa, Okla., and Otto M. Smith, Director, Research Foundation, Oklahoma Agricultural & Mechanical College, Stillwater, Okla.*

DURING an investigation of fluoridation agents, it was concluded that the direct use of fluorspar ( $\text{CaF}_2$ ) was not feasible, but an indirect means of using it was discovered. Continued research indicated that this indirect means has great possibilities for practical use. Much attention has therefore been devoted to the manufacture and testing of a new material designated as "Flural \*\*" because of its function as a source of both alum and fluoride.

Flural is made by a digestion reaction which produces a solution containing aluminum, fluoride, and sulfate ions. The solution is evaporated to a water content of 18-30 per cent (as determined by distillation of the water with xylene), and the glassy solid obtained when the solution is cooled, is ground and, if necessary, further dried to give a dry, free-flowing material that resembles regular filter alum in appearance.

It should be understood that Flural is not considered applicable for water treatment in operations in which the water is not filtered after the alum-fluoride component has been added. The values of Flural derive in part from the reaction of the aluminum as a

coagulant and in part from the presence of the fluoride which carries through in solution into the finished filtered water.

The relative concentrations of aluminum and fluoride can be varied through a wide range by varying the weights of reactants. One reaction mixture yields a Flural which approximates in composition the formula  $\text{AlFSO}_4 \cdot x\text{H}_2\text{O}$ . Another mixture increases the ratio of fluoride, and the composition can be represented by the formula  $\text{Al}_2\text{F}_4\text{SO}_4 \cdot x\text{H}_2\text{O}$ . Intermediate compositions can be obtained. Flural production will probably be restricted to pilot-plant scale (500 lb per day) until the middle of 1952 or later. The compositions listed in Table 1 are typical of early pilot-plant production. As improvements in the process are made, the amounts of insoluble matter will probably be diminished.

As ordinarily prepared, Flural is a noncrystalline material that is, except for the small amount of impurity, completely soluble in water. Carefully dried laboratory preparations have been quite free of insoluble matter.

### Mutual Influences of F and Al Ions

The well known affinity between fluoride and aluminum ions renders

\* An experimental product of the Ozark-Mahoning Co., Tulsa, Okla.

questionable the practicability of adding both simultaneously with the expectation that all of the aluminum will form a floc and all of the fluoride will go into solution. Hydrous alumina is known to be an effective agent for removal of excess fluoride from water (1-4), and it has been considered inadvisable to add sodium fluoride before alum in plants practising fluoridation because of the resulting fluoride loss (5).

The strong affinity between fluoride and aluminum ions may result in the formation of various undesirable complexes. In the pH range of drinking water, the solubility of aluminum when combined as  $\text{AlF}_6^-$  ion, for example, is considerably greater than when it is in combination as  $\text{Al}(\text{OH})_3$  or  $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ . This fact leads to the fear that much of the flocculating capacity of the aluminum in Flural may be wasted because it will remain in solution as the complex anion. In considering the formation of complexes by the fluoride and aluminum ions, other misgivings are occasioned about the availability of the fluoride for the inhibition of dental caries.

### Floc and Fluoride Ion Removal

Although alum floc has been shown to absorb excess fluoride from water, it should be noted that fluoride removal has never been complete (1-4). Kempf, Galligan, and Greenwood reported a reduction from 7-10 ppm to 1.5-2 ppm F by use of aluminum sulfate (1). Finkbeiner used lime and alum to effect a reduction to 1.2 ppm F (2). Boruff, Buswell, and Upton found variable effects on fluoride removal depending on the cations present in the water (3). Scott, Ey, and Waring reported data which have been used in plotting the curves of Fig. 1

(4). These data show straight-line relationships between the alum dosages and the logarithms of the  $\text{F}^-$  remaining in solution at initial concentrations of 1.7 and 3.0 ppm F, and a slight deviation from a straight line at higher alum dosages of 6.0 ppm F.

With initial  $\text{F}^-$  concentrations as great as 6 ppm and alum dosages as great as 342 ppm, the relationship can be expressed by the equation:

$$\begin{aligned} \text{ppm F}^- \text{ remaining in solution} \\ = \text{ppm F}^- \text{ initially present} \\ \times \text{antilog} [-k (\text{ppm alum added})] \end{aligned}$$

in which  $k$  is 0.0209.

TABLE 1  
*Typical Compositions of Early  
Pilot-Plant Products*

Component	Lot Designation	
	M-3 -59	M-3 -64
Fluorine—per cent	18	11
Available $\text{Al}_2\text{O}_3$ —per cent	21	26
Ratio F:Al (approx.)	2:1	1:1
Insoluble matter—per cent	4	1
Water (by xylene)—per cent	18	15
Flocculating capacity, Flural:Regular Alum	1.2 : 1.5	

By means of this equation it may be computed that alum treatment of 86 ppm of a water with 1 ppm  $\text{F}^-$  initially would reduce the F content to 0.8 ppm. Curve D in Fig. 1 shows the results to be expected with 1 ppm F from the Scott, Ey, and Waring report (4). The tentative conclusion from this work, then, is that, if the fluoride concentration and the alum dosage are in the usually desirable ranges, the amount of fluoride removed will be very small—probably no greater than 0.1 ppm.

### Floc and Fluoride From Flural

Boruff, Buswell, and Upton (3) observed the effects of various ions on fluoride removal by alum. Their observation of effects of various ions on fluoride removal by alum suggests that conclusions derived from NaF-alum-studies are not necessarily tenable when the F and  $\text{Al}_2(\text{SO}_4)_3$  are combined as  $\text{AlF}(\text{SO}_4)_2$ . A study was therefore made of the addition of F and alum simultaneously from Flural and of the persistence of the fluoride ion

TABLE 2  
Effect of Flural Floc on Various Fluoride Concentrations\*

Flural Content ppm	Calculated Equiv. Alum—ppm	Fluoride Content—ppm		Fluoride Lost From Solution ppm
		Before Floc	After Floc	
0	0	0	0	0
4.3	6.3	0.5	0.5	0
8.6	12.8	0.9	0.9	0
17.1	25.7	1.8	1.8	0
34.2	51.3	3.5	2.6	0.9
68.4	102.6	6.8	5.6	1.2

\* Floc and F from Flural, distilled water; flocculation by 0.1*N* NaOH  $\approx$   $\text{Al}^{3+}$ ; F determined by distillation followed by Lamar modification of the standard method (6).

in the water during the separation of the floc.

The results of this study given in Table 2 indicate that the floc from Flural is similar to that from alum, and, when the fluoride concentration rises to approximately 2.5 ppm, the floc from Flural begins to sorb some fluoride.

### Effect of Fluoride on Floc

Preliminary rough qualitative experiments indicated that a slightly greater aluminum ion concentration was necessary when fluoride was present be-

fore a recognizable precipitate was obtained. Table 3, however, shows that this preliminary indication is not confirmed by quantitative studies involving the simultaneous introduction of fluoride and aluminum by the use of Flural. The presence of fluoride in the water did not increase the aluminum content of the filtered waters, and hence it was concluded that the  $\text{AlF}_6^-$  ion was not formed or, if formed, did not persist, as persistence would have permitted more aluminum to escape precipitation. Because the aluminum did not come into the filtrate in an unusual amount when the fluoride was present, it was also concluded that flocculation was not affected by the  $\text{F}^-$ .

### Caries-Inhibitory Activity

To establish definitely that Flural behaves as a normal fluoride in preventing dental caries, three-month studies were made at the University of Rochester of three groups of hamsters (close litter mating) receiving a caries-producing diet. The control group received the diet and drinking water with no significant amount of fluoride. A second control or comparison group had the same diet, but the drinking water contained enough sodium fluoride to protect against carious attack. The diet of third group was the same except that the water was fluoridated by use of Flural.

The results (Table 4) show that Flural is as effective as sodium fluoride in preventing caries.

### Toxicity of Flural

The acute toxicity of Flural was the subject of another study at the University of Rochester. In this study, 200-g albino rats were subjected to varying doses administered intraperitoneally or orally to determine the lethal dosage

( $LD_{50}$ ) at which 50 per cent mortality occurred within 24 hours. The results, compiled in Table 5 show Flural, by weight, to be approximately one-eighth as toxic as sodium fluoride or, on the basis of fluoride content, to be approximately half as toxic.

Although the present studies have not included sodium fluosilicate, it is of interest to compare data from the literature with those presented here on sodium fluoride and Flural. Hampel (9) has included some toxicological

would be 5.5 g for sodium fluoride, 8.5 g for sodium fluosilicate and 45 g for Flural. These calculated values for the  $NaF$  and  $Na_2SiF_6$  come within the range reported in the literature for acutely toxic levels of these two salts (10).

### Trial in Water Plants

As the preliminary laboratory investigations indicated Flural was satisfactory from the standpoint of caries inhibition, acute toxicity, coagulation

TABLE 3  
Effect of Fluoride on Aluminum Content of Finished Water

Coagulant	Concentration— $\mu\text{pm}$				Source of Sample	Analysis		
	Alum	Fluoride	Al $^{+++}$					
			Before Flocculation	After Flocculation*				
Alum	17.1	0	1.5	0.04	Laboratory	Spectrographic		
Flural	29.1	1.6	2.6	0.06	Laboratory	Spectrographic		
Alum	85.6	0	7.5	0.31	Laboratory	Spectrographic		
Flural	145.5	8.0	13.0	0.32	Laboratory	Spectrographic		
Alum	171.2	0	15.0	0.18	Laboratory	Spectrographic		
Flural	291.0	16.0	26.0	0.45	Laboratory	Spectrographic		
Alum and Flural	5.1	1.0	0.5	0.40	Ottawa Plant	Colorimetric		
Flural	8.6	1.0	0.8	0.05	Ponca City Plant	Colorimetric		

\* Solubility measurements of  $Al(OH)_3$  in water would lead to an expected 0.5 ppm Al $^{+++}$  content (7).

information in his survey of the properties and possible uses of sodium fluosilicate, and Cox and Hodge (10) have also surveyed and discussed its toxicity. Data from these sources included in Table 5 indicate that sodium fluosilicate is less toxic than sodium fluoride and, on the basis of fluoride content, is comparable in toxicity to Flural.

If the same ratio of toxicant to recipient found in rats applies to man, it may be calculated that the  $LD_{50}$  by oral administration for a 150-lb. man

and fluoridation, actual plant tests were made to provide a complete answer on the effectiveness of Flural. Full-scale experimental runs were made at Cushing, Stillwater, Ponca City, and Clinton, Okla., and at Ottawa, Kan. The concentration ranges of dissolved solids in the five waters are given in Table 6.

### Cushing and Stillwater, Okla.

The first plant tests were made at Cushing and Stillwater, Okla., during

the spring and summer of 1950. The primary purpose of these first tests was to determine whether Flural would feed properly through the regular alum feeders and would give normal flocculation. The fluoride content of the filtered water was determined, but no attempt was made to obtain the equilibrium conditions throughout the plant necessary to study the efficiency of fluoridation. The conclusions drawn from these two trials were: [1] that the Flural behaved just as ordinary filter alum in feeding, dissolving, and

ened water. The construction of the Ottawa plant insured a constant flow of water at the points of application of the sodium fluoride and of the carbon when needed.

The water is obtained from the Marais des Cygnes River and is quite variable in composition. The plant is unusual as it has two full complements of feeding equipment, mixing facilities, carbonating units and sedimentation basins. The raw water is coagulated, softened and carbonated in the primary unit and allowed to settle. The capaci-

TABLE 4  
*Caries-Inhibitory Action of Flural in Syrian Hamsters*

Group	Fluoride Content ppm	Sex	No. of Animals	Decayed Molars After 3 Months* (mean)	No. of Cavities (mean)	Area of Tooth Affected† (mean)	Total Caries Score† (mean)
Control	None	Male Female	8 11	12 11	17 19	37 23	101 55
NaF	17 17	Male Female	11 10	5 2	7 3	5 2	10 2
Flural	16 16	Male Female	11 11	4 3	4 4	3 3	5 6

\* Full complement is 12.

† A measure of the volume of dental tissue destroyed; arbitrary unit is related to the area of the cusp of molar teeth in the hamster (8).

coagulating; and [2] that most of the fluoride came through the process into the finished water.

#### *Ottawa, Kan.*

At Ottawa, Kan., the city water supply has been fluoridated with sodium fluoride. A trial with Flural—made from January 9 to January 26, 1951—was of particular interest, therefore, because it permitted a comparison of the two methods. Furthermore, the Flural used would be added to a soft-

ties of the settling basins permit a constant flow from the primary settling basin to the secondary treating unit, at which point carbon, when needed, and a small amount of alum are added. After mixing, a second recarbonation is given, and the water is settled in preparation for filtering.

During the test, Flural was added in place of the alum in the secondary feeder, and use of the sodium fluoride was discontinued. Because the alum requirement was so low, the M-3-59 Flural (Table 1), with 18 per cent F

and an F:Al atomic ratio of approximately 2:1, was used.

The plant was operated for eighteen days using Flural, and, after three days of equipment adjustment, a feed rate of 6 ppm was maintained for fifteen days. During this time, the F content of the water in the clear well ranged between 0.9 and 1.0 ppm with an average of 0.94 ppm. At the 6-ppm rate, 1.09 ppm of F should have been added. Thus, with the 0.2 ppm naturally present, there should have been 1.29, but only 0.94 was obtained, leaving un-

soon as the product is commercially available.

*Ponca City, Okla.*

Tests were conducted at Ponca City, Okla., on February 14 and 15, 1951. Ponca City uses an average of 4.5 mgd; its plant is of conventional design, the water coming from an artificial lake and wells. The average alum feed is approximately 19 ppm. No difficulty was experienced in feeding Flural with the Omega equipment,\* as the flow was similar to that of regular filter alum,

TABLE 5  
*Comparison of Acute Toxicity of Sodium Fluoride, Sodium Fluosilicate, and Flural*

Application	LD <sub>50</sub> (24 hr.) for 200-g. Albino Rats		
	NaF	Na <sub>2</sub> SiF <sub>6</sub>	Flural
Intraperitoneal	11 mg. F/kg. 24 mg. NaF/kg.	— —	18.5 mg. F/kg. 185 mg. Flural/kg.
Oral	36 mg. F/kg. 80 mg. NaF/kg.	— 125 mg. Na <sub>2</sub> SiF <sub>6</sub> /kg.*	66 mg. F/kg. 660 mg. Flural/kg.
Calculated probable LD for 150-lb. man	5.5 g.†	8.5 g.†	45 g.

\* See Ref. 9.

† See Ref. 11.

accounted for 0.34 ppm of F. The principal reason for this relatively great apparent loss of fluorine is believed to be the physical form of the Flural, although the presence of activated carbon in the water may also have contributed. Because the Flural used in this trial was screened through 8-mesh sieves and contained only a small amount of fine material, it is probable that many particles were never completely dissolved.

The results of this trial and the convenience of fluoride addition were such that the city plans to use Flural as

except that, for a given setting, approximately 20 per cent less Flural was discharged. The Flural used contained 10.8 per cent of F and 25.7 per cent of Al as Al<sub>2</sub>O<sub>3</sub>. During the four-day trial, the only alum used was that in the Flural. Flocculation appeared normal at all times.

The two operators and the city water chemist periodically examined the floc and reported that it was as good as that obtained when an equivalent amount of alum was used. The ef-

\* Product of Omega Machine Co., Providence, R. I.

Effectiveness of the Flural as a fluoridating agent is indicated in Table 7, which shows that a total calculated F content of 1.08 ppm appeared in the filtered water as 1.0 ppm.

#### Clinton, Okla.

The same grade of Flural was used at Clinton, Okla., on March 19-23, 1951, as had been used at Ponca City. The feed rates are shown in Table 7.

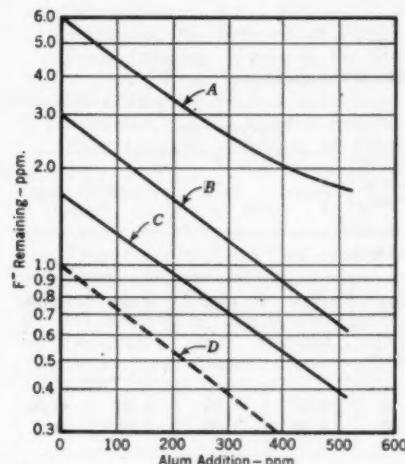


Fig. 1. Sorption of F- by Alum Floc

Curve A shows results at 6.0 ppm F-, Curve B at 3.0 ppm, Curve C at 1.7 ppm, and Curve D at 1.0 ppm.

In each test, equilibrium was established throughout the plant for sufficient time to insure reliable observations and results. A total of 1.7 and 1.1 ppm of F were imparted to the water, with loss of 0.2 ppm in the first test and 0 in the second.

#### Coagulation

Test 3 in Table 7 yielded excellent coagulation and equivalent floc size in

comparison with the filter alum dosage of 30 ppm that was used before and after the test. It should be noted that alum as well as Flural was added in Test 3. In Test 2, although the water was coagulated, the floc was quite small; the settled water was nevertheless sufficiently well clarified and coagulated for effective filtration.

In the five full-scale plant tests, considerable reliance was placed upon the judgment of the plant operators. The consensus of the ten experienced operators was that clarification obtained

TABLE 6  
Concentrations of Dissolved Solids  
in Plant Test Waters

Material	Concentration—ppm
Calcium	24-32
Magnesium	6-17
Sodium and Potassium	11-47
Bicarbonate	98-196
Sulfate	11-71
Chloride	7-30
Nitrate	1.2-6.5
Silica	3-4
Dissolved Solids	134-236
Hardness as CaCO <sub>3</sub>	92-150

with Flural was as good as that obtained with filter alum when equal alumina dosages were used. Good coagulation was obtained in all five plants, and, to the extent observable in short runs, the effectiveness of the filters appeared unchanged. The only apparent difference was the reduction in floc size.

#### Conclusions

*Flocculation.* The alumina in Flural appeared to behave the same as alumina from regular filter alum. The alumina content of the Flural was higher than

that of filter alum, and, therefore, less of the former was required for normal flocculation.

*Efficiency as a fluoridating agent.* At Ottawa, Kan., only 70 per cent of the total fluoride (F in added Flural and natural F in water) was found in the filtered water. At Ponca City approximately 10 per cent of the total F was not accounted for. At Clinton no F was lost when the Flural rate was sufficient to give 1.1 ppm of total F and 12

*Fluctuating alum requirements.* The alum feed throughout the test periods was nearly constant. The method of varying the alum dosage while maintaining a constant fluoride addition is indicated by Test 3 in Table 7. The Flural composition and feed rate were adjusted to give the desired fluoride addition at the usual alum requirement, and, when the water required additional alum, it was added by an auxiliary feeder.

TABLE 7  
*Use of Flural in Three City Water Supplies*

Alum— $\mu\text{pm}$					Fluorine— $\mu\text{pm}$				
Test	Flural	Equiv. in Filter Alum	Alum	Total	Added by Flural	Natural	Total	Found	Loss
Ponca City, Okla.									
1	8.56	13.01	—	13.01	0.93	0.15	1.08	1.00	0.08
Clinton, Okla.									
2	13.01	19.52	—	19.52	1.40	0.30	1.70	1.50	0.20
3	7.19	10.79	20.54	31.33	0.80	0.30	1.10	1.10	0
Ottawa, Kansas									
4	6.16	7.70	—	7.70	1.09	0.20	1.29	0.94	0.34

per cent when the total expected F was 1.7 ppm. These calculations of expected total F are based on natural F contents of 0.1 to 0.3 ppm. Analytical errors become greater in the 0.0–0.5-ppm F range, so that the calculated F may be in error by as much as  $\pm 0.1$  ppm, and the proportional recovery may similarly be somewhat inaccurate.

*Addition of Flural.* Flural was always added to the water by means of alum feeders, which performed as well as when feeding alum.

## Production and Costs

Manufacture of Flural is expected to remain on an experimental basis (pilot plant capacity approximately 500 lb per day) for some time, with commercial production not planned before the summer of 1952. The cost is expected to be approximately 5¢ per lb.

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## Counterflow Regeneration of Cation Exchanger in Partial Demineralization of Brackish Waters

By K. S. Spiegler, Walter Juda and Morris Carron

*A contribution to the Journal by K. S. Spiegler, Walter Juda, and Morris Carron, all of Water Research Sect., Daniel Sieff Research Inst., Weizmann Inst. of Science, Rehovot, Israel.*

**A**LTHOUGH brackish water is found in many parts of the world, its frequent occurrence in arid regions is particularly troublesome, as alternative fresh water supplies are rarely available. Common causes of high salinity are percolation of the water through marine formations and contamination by sea water.

The nature and concentration of dissolved salts vary between widely separated limits. Many brackish water sources have a salinity between 1,000 and 2,500 ppm, which is greater than the permissible limit in the U.S. Public Health Service standards (1), although considerably less than the salinity of sea water. Such water is harmful to a variety of soils and crops, especially in an arid climate (2).

The most economical method of desalinization of low-salinity waters is ion exchange, the cost of which is in approximate proportion to the salinity of the raw water. The cost of distillation, on the other hand, is almost unrelated to the degree of salinity. Compression distillation is the most economical method for producing fresh water from sea water (3, 4), but, except in areas in which very cheap fuel is available, all forms of distillation are too expensive at present for large-scale desalinization. Investigation of

the application of ion-exchange methods was considered worth while, therefore, to demineralize brackish waters that contain less than 2,500 ppm total dissolved solids.

The initial data reported in this paper stem from the operation of a pilot plant utilizing a modification of ion-exchange demineralization developed by the Palestine Research Associates, Cambridge, Mass., and the Weizmann Institute of Science, Rehovot, Israel. The pilot-plant experiments were undertaken on the basis of previous laboratory work (5).

The overall aim of the various methods of brackish-water desalinization under test at the Weizmann Institute is to achieve maximum economy of regenerant chemicals, taking into consideration the cost of purified water lost in the regenerating solutions and in the washes. The savings obtained through efficient use of regenerants are particularly important in times of rising chemical prices and of allocations due to scarcity of such chemicals as sulfur. As overall treatment costs represent an economic balance between operating costs and amortization, the choice among several alternate steps sometimes depends upon the size of the contemplated installation. For example, the use of lime instead

of soda ash or caustic—if feasible—constitutes a significant saving in chemical cost but requires a greater investment in handling and in equipment. Although the latter cost is relatively small in large-scale installations, in small installations, it may exceed the amount saved in chemicals. Although they affect the overall economy less, efficient use of acid and savings in purified wash waters are valuable because they operate independently of the size of the installation. Discussion is therefore limited to the effect of operating cation exchangers with counterflow of acid and water through the demineralizer in a three-step, partial-demineralization process. This method was developed to recover sodium sulfate from the spent cation-exchanger regenerant by solar evaporation.

While these and other experiments were in progress, monobed deionization was suggested for partial demineralization, as it required comparatively simple equipment and offered great economy of regenerants (6). No data on the partial demineralization of brackish waters by the monobed method have been reported so far, but such information should prove to be of great interest when released.

### Principle of Method

The clear raw water passes through a base-exchange softener and then through two pairs of demineralizers, each consisting of partially regenerated, strongly acid cation exchanger, and weakly basic anion exchanger. The cation exchangers are regenerated with sulfuric acid which is passed down through them. In the subsequent purification step, the water passes the cation exchanger in the opposite direction. By this procedure, great acid-regenerant efficiency is obtained.

The "counterflow" method of partial demineralization was highly successful in achieving economy of regenerant. In most conventional deionization units, regenerants are passed through the columns in the same direction as the water and the resinous exchangers are completely regenerated. A considerable excess of regenerant is necessary if the exchangers are strongly acid or strongly basic. Part of the excess can be salvaged by reusing it in the next regeneration. Obviously contact between resin and water in a continuous counterflow process would be desirable, thus equilibrating the incoming raw water with the most exhausted resin and freshly regenerated resin with the exchanger effluent. As no economical counter-current system is currently available, however, regular columns are used, but an initial concentration gradient of the hydrogen form is produced in them by partial regeneration with sulfuric acid. In the regeneration, the lower layers of the cation exchange column absorb all hydrogen ions left in the regenerant after passage through the almost completely regenerated top layer, making these ions available for exchange in the subsequent treatment step. The result of the procedure is full use of the regenerant, the sulfuric acid being completely converted into sodium sulfate. In the demineralization step, the effluent from the first hydrogen-ion exchanger still contains some of the salts originally present in the raw water. The acids are adsorbed in a weakly basic anion exchanger, which can be very efficiently regenerated. In the second pair of columns, another fraction of the salts is removed. Unlike complete demineralization processes characterized by sharp breakthrough, effluent salinity from the final column

gradually rises. The partly demineralized column effluent is collected in a storage tank and the process continued until the average salinity of the treated water reaches the allowable maximum.

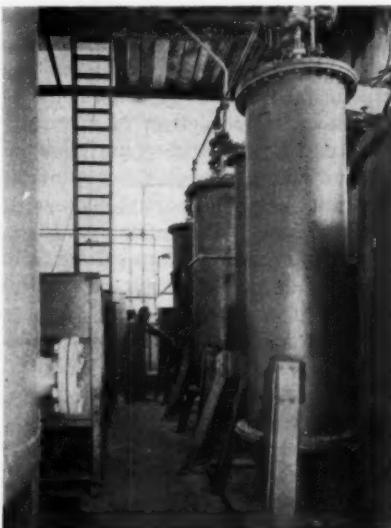
The laboratory experiments of Kortschak, Gill and Payne (7), which were published while this project was in progress, confirm the above conclusions on the advantages of the countercurrent technique.

Although a regenerant efficiency of 100 per cent is theoretically possible, unavoidable losses of regenerants occur in actual plant operation from partial weakening of the resin by the wash water and draining of the partly demineralized water from the columns before regeneration. These losses increase with the salinity of the raw water and are quite considerable for brackish water. Regenerant efficiencies in actual plant practice are therefore appreciably less than those determined in laboratory experiments. In the pilot plant experiments reported below, overall acid regenerant efficiencies were approximately 70 per cent when about 1*N* acid (approximately 5 per cent  $H_2SO_4$ ) was used. Weaker acid concentrations are expected to give better efficiency, because the extent of regeneration per equivalent of acid improves with acid dilution.

Calcium and magnesium are more difficult to remove from the hydrogen-ion exchanger than sodium. Also, the precipitation of calcium sulfate in the column decreases its efficiency. These considerations, as well as the desirability of recovering pure sodium sulfate from the spent hydrogen-ion exchanger effluent, led to the inclusion in the system of a base exchange softener. The additional operating costs

are not critical, because in the Negev area of Israel, for which application of this process is considered, as well as in many other arid areas, sodium chloride is often available at low cost.

Sodium-hydrogen equilibria for several commercial cation exchangers were investigated (5), and, on the



**Fig. 1. Pilot Plant at Weizmann Institute**  
*This plant consists of two raw-water tanks, three filters, a softening column, three pairs of cation- and anion-exchange columns, two regenerant tanks, a lime-water-regeneration system for the anion-exchange columns, and two treated-water tanks.*

basis of these findings, the weakest of the sulfonic-acid exchangers studied—Dowex-30\*—was chosen. Commercially available synthetic cation exchangers are of the sulfonic or carboxylic acid type. The latter has very high regenerant efficiency, but salt-

\* Product of The Dow Chemical Co., Midland, Mich.

splitting is incomplete and the exchange rate poor. The sulfonic acid cation exchangers are strongly acid and require larger amounts of acid for regeneration.

As the regeneration level of the hydrogen-ion exchanger column did not exceed a third of its total capacity, a considerably greater amount of cation exchanger than of the weakly basic anion exchanger was required. Amberlite IR-4B\* was chosen as anion exchanger. This material is weakly basic and can be almost completely regenerated with a little more than the theoretical amount of caustic regenerant.

To reduce costs, regeneration of the anion exchanger by lime water was studied. The spent regenerant from the anion exchanger was recirculated to the lime-dissolving tank (8), but investigation of this method was not concluded. In the pilot plant experiments reported below, sodium carbonate was used for the regeneration of the anion exchangers.

### Pilot Plant

The pilot plant shown in Fig. 1 contained two 3,000-gal raw-water tanks, raw-water pumps, a softening column 2 ft in diam and 8 ft high containing Dowex-30, and two pairs of cation- and anion-exchange columns containing Dowex-30 and Amberlite IR-4B, respectively. In addition, there was other equipment not used in the experiments described below. The cation- and anion-exchange columns were each 8 ft high and 1 ft in diam. The resins were supported on Norton<sup>†</sup> porous filter plates. All valves in contact with

acid solutions were made of stainless steel. The treated water was collected in two 3,000-gal. treated-water tanks. Sulfuric acid and sodium carbonate regenerant solutions were prepared in 150-gal. tanks, gravity fed through the columns.

The simulated raw water was prepared in accordance with the composition of the natural water to be demineralized and pumped through the columns. Samples taken at different stages of the process and at various points were analyzed. Treatment was stopped when the second pair of columns neared exhaustion. In many cycles, spent regenerants were reused. Fresh regenerant solutions were analyzed and the spent regenerants tested at various stages of the regeneration.

The columns were rinsed with much smaller amounts of water than are necessary in complete demineralization, as the presence of the remaining small portions of salt, which are most difficult to remove from the columns, does not seriously interfere with partial demineralization.

Solar evaporation of spent regenerants as well as synthetic sodium sulfate solutions was studied in 11-sq ft open tanks, 4 and 8 in. deep, respectively (Fig. 2), and also in closed solar stills (Fig. 3) in which the condensate is recovered (9).

### Results

Table 1 shows pilot plant operating data on the demineralization of a brackish water the mineral composition of which corresponds to that of a spring near Haifa, Israel, which yields a minimum flow of 750,000 gph. These data represent the average figures for four consecutive cycles in which countercurrent regeneration of the Dowex-30 cation exchangers was

\* Product of Rohm and Haas Co., Philadelphia, Pa.

† Product of Norton Co., Worcester, Mass.

accomplished by sulfuric acid and regular parallel-current regeneration was used for the Amberlite IR-4B anion exchangers and the Dowex-30 softener. The spent regenerants were reused for another regeneration. The raw water contains 540 ppm hardness as  $\text{CaCO}_3$  and 1,280 ppm of dissolved salts as  $\text{CaCO}_3$ , of which two-thirds are chlor-

ness in the effluent was probably due to a small residue of calcium carbonate precipitate in the anion-exchange columns from a previous regeneration with lime water. Treated water should normally be completely soft. Slight hardness desirable in municipal distribution systems can be added by bleeding in a small fraction of un-

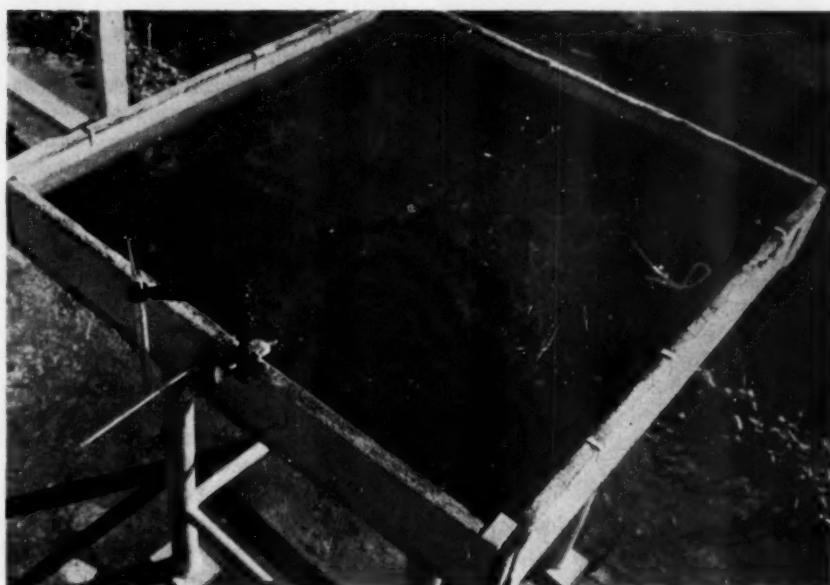


Fig. 2. Open Solar Evaporation Tank

This tank, which is 8 in. deep, was used for measuring solar evaporation of sodium sulfate solution. It offered 11 sq ft of surface area.

ides. The treatment reduced the dissolved salts to 487 ppm as  $\text{CaCO}_3$  and hardness to 50 ppm as  $\text{CaCO}_3$ . The treated water is well suited for municipal use. Overall regenerant efficiencies for acid and alkali were more than two-thirds of the theoretical values and less than half of the theoretical value for sodium chloride. The slight hard-

treated hard water. Table 2 summarizes the data on the regenerants.

Similar results were obtained in the demineralization of a water the mineral composition of which corresponded to that of a spring near Beth Shean, Israel. This water contains approximately 2,000 ppm of total dissolved solids. The changes in the

composition of the water after passage through the first and second pair of demineralizers are graphically presented in Fig. 4. Table 3 gives a comparison of the composition of the raw water and the bulk of the treated water as sampled from the treated-water tanks.

In some laboratory experiments, demineralization of a highly brackish water containing 7,624 ppm of total dissolved solids was investigated. Under normal circumstances, compression distillation should prove more economical than chemical demineralization for a

TABLE 1  
*Demineralization of Spring Water\**

Material	Influent— ppm	Effluent— ppm
Hardness (as $\text{CaCO}_3$ )	540	50
$\text{Cl}^-$	622	214
$\text{SO}_4^{2-}$	126	4
$\text{HCO}_3^-$	334	221
$\text{Na}^+$ (by difference)	340	200
pH	8.51	7.01

\* Table includes average output for four full cycles of 3,600-gal average output. The flow rate is approximately 5 gpm.

water of such high salinity, but it was decided to investigate resin performance regardless. The resins used were Dowex-50 and Amberlite IR-4B. The chloride concentration of the raw water was reduced from 3,040 ppm to 250 ppm, and the hardness from 2,730 to 65 ppm. Acid and alkali regenerant efficiencies were approximately two-thirds of the theoretical values but that for sodium chloride was only approximately 30 per cent. When Amberlite IR-4B regenerated with soda ash was used as anion exchanger, gas evolution was observed in the anion-exchange

column. This action is due to the formation of resin carbonate during the regeneration, which liberates carbon dioxide upon contact with the strongly acid cation-exchanger effluent. As this gas evolution caused operating difficulties, caustic soda was subsequently used as a regenerant. Because of the great amounts of regenerants and wash water required and the comparative shortness of the cycles, ion-exchange demineralization of waters of such high salinity is not considered economical.

When the Amberlite IR-4B columns were regenerated with lime water, cal-

TABLE 2

*Regenerants Used in Demineralization of Spring Water Described in Table 1*

Regenerant*	Avg. Concen. lb per gal	Amt. per Cycle lb	Overall Re- generant Eff. per cent
NaCl	0.41	44.5	38.5
$\text{H}_2\text{SO}_4$	0.41	34.9	67.7
$\text{Na}_2\text{CO}_3$	0.32	35.9	72.4

\*As pure compounds.

cium carbonate was precipitated, thus contaminating the columns and impairing their efficiency in the following treatment step. The carbonate or bicarbonate in the Amberlite IR-4B columns resulted partly from the previous regenerations with soda ash but probably also from partial absorption of carbon dioxide from the cation exchange effluent. This effect could be prevented by using a more weakly basic anion exchanger.

The acid effluent from the cation exchanger was found to be free of bacteria, whereas the anion-exchanger effluent was heavily contaminated. Studies of the effect of partial demineraliza-

tion on bacteria were discussed in a previous publication (10).

### Discussion

To make partial demineralization of brackish waters economical, use of the absolute minimum of chemicals for regeneration is imperative. In theory, approximately 4 tons of both sulfuric acid (66 Bé) and soda ash are required to reduce the salinity of 1 mil gal by 1,000 ppm as sodium chloride. At February 1951 New York prices, this requirement corresponds to chemical costs of approximately 20¢ per

softening involves further expense for sodium chloride. If half the theoretical amount of sodium sulfate could be recovered as a pure product, however, a saving would be made of approximately 12¢ per 1,000 gal of water treated. Quite pure Glauber's salt was obtained when cation-exchanger effluent was concentrated by solar evaporation, yet it remains to be seen under which conditions recovery of sodium sulfate would be economical on an industrial scale.

TABLE 3  
*Demineralization of Second Type Spring Water*

Material	Raw	Treated
Cl <sup>-</sup>	860	240
SO <sub>4</sub> <sup>2-</sup>	98	0
HCO <sub>3</sub> <sup>-</sup>	270	97
Hardness (as CaCO <sub>3</sub> )	729	trace
Conductivity as NaCl*	1,796	479
pH	7.98	6.66

\* Calculated from measurements obtained with an Industrial Instruments conductance meter.

1,000 gal treated. If burnt lime is substituted for soda ash, the theoretical requirement would be approximately 2.2 tons of crude burnt lime per 1,000 gal treated. Use of lime would reduce costs for the theoretical amounts of chemicals to 10¢ per 1,000 gal with 1,000 ppm NaCl removal.

These figures represent the theoretical minimum that any ion-exchange method may approach except if regeneration by steam or hot water should prove feasible. Acid and alkali regenerant requirements were 50 per cent greater than theoretical in these experiments, and the use of pre-

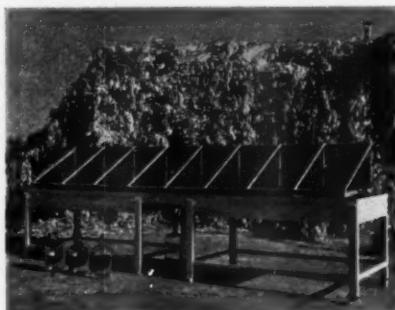


Fig. 3. Closed Solar Evaporation Tank  
Bottle in which the condensate is collected is shown under the stand. This type of still was used for evaporation of sodium sulfate solutions.

Attrition of cation exchangers is estimated to be several per cent annually and contributes but little to the cost of the process. Attrition of the less stable and more expensive anion exchanger, however, may amount to 5-10¢ per 1,000 gal treated (11).

In large installations, when compared with chemical costs and resin attrition, plant depreciation and labor are comparatively small factors. Four cents per 1,000 gal treated is a reasonable figure for depreciation and interest. The cost of demineralization by

the process described above, using acid and alkali at 70 per cent efficiency, should be approximately 35-40¢ per 1,000 gal treated with 1,000 ppm sodium chloride removed. To this amount must be added the costs of

ash and by reclaiming sodium sulfate. These figures do not include the cost of distribution.

As the salinity of the raw water increases, ion-exchange demineralization becomes less economical, because regenerant and rinse water requirements increase almost proportionally with the salinity and in inverse proportion to the length of the period between successive regenerations. Partial demineralization by ion exchange must still be considered a fairly expensive process. In arid areas where lack of available fresh water supplies for urban and industrial use makes the use of moderately brackish water inescapable, however, this method of treatment may prove to be the least expensive.

### Summary

Pilot plant data are reported on partial demineralization of moderately brackish waters. To achieve maximum economy of sulfuric acid used for regeneration, the countercurrent technique of partial regeneration of the hydrogen-ion-exchangers was used. The pilot plant contained a 25-cu ft Dowex-30 softener, two 25-cu ft Dowex-30 hydrogen-ion-exchange columns, and two 6-cu ft Amberlite IR-4B anion-exchange columns. Acid and soda ash regenerant efficiencies were approximately 70 per cent of the theoretical values and salt regenerant efficiency approximately 40 per cent. The total dissolved salts were reduced from 1,500-2,000 to 500 ppm. Sodium sulfate was recovered from small batches of the spent hydrogen-ion-exchanger effluent by solar evaporation. Partial demineralization by ion exchange should prove to be the most economical method of treatment for waters containing less than 2,000 ppm dissolved solids. The cost of demin-

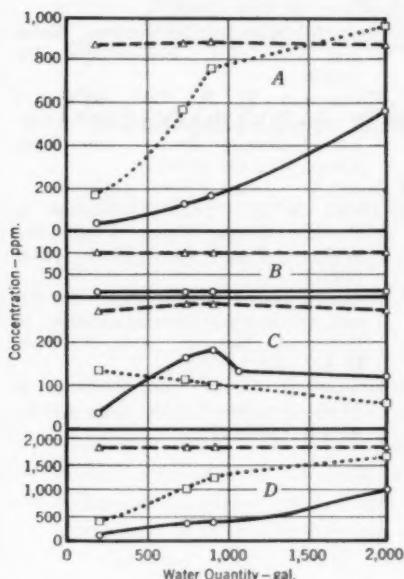


Fig. 4. Composition Changes in Partial Demineralization

In A is shown removal of chlorides as  $\text{Cl}^-$ ; in B, removal of sulfates as  $\text{SO}_4^{2-}$ ; in C, removal of bicarbonate as  $\text{HCO}_3^-$ ; and in D, the reduction of conductivity expressed as  $\text{NaCl}$ . Broken lines show concentrations in raw water. Dotted lines show effluent from first pair of demineralizers. Solid lines show effluent from second pair of demineralizers.

chemical, labor, transportation and sodium chloride for presoftening, the charges for which depend largely upon local factors, but will usually not exceed 20¢ per 1,000 gal. Future reductions in demineralization costs may be effected by using lime instead of soda

eralization by the method presented is estimated to be 60¢ per 1,000 gal treated with 1,000 ppm solids (as NaCl) removed.

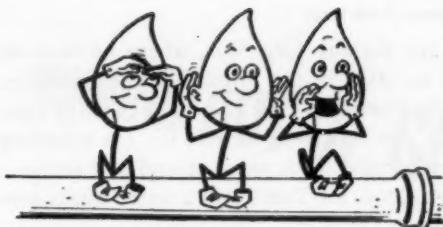
### Acknowledgment

The authors wish to thank Y. Hagin of the Agricultural Experimental Station of the Jewish Agency, Rehovot, Israel, for valuable assistance.

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## *Percolation and Runoff*

**Scrap!** Don't scrap your New Year's resolutions; make your New Year's resolutions scrap! Steel production during 1952 will require at least 36,000,000 tons of iron and steel scrap—a large order, but an essential one. Steel can be made without scrap; but better steel faster is what scrap means and what the nation needs.

You may not think you have even a million tons, but you'll be surprised at what you'll turn up when you really start looking. A piano manufacturer recently uncovered 23 tons in a single plant. You too can make beautiful music! Take a chalk walk—put an "X" on everything that can go. Make a scrapbook of your "atticware," your museum pieces, your "broken-down-but-not-given-ups." Then call in your local scrap dealer. You won't even have to give him the works; he'll be glad to buy it from you.

Get hep! Scrap scrap! It's needed Now!

**A scrap scrap** almost resulted last month when it was revealed that two carloads of steel pipe that had been snafued to Robins air force base in Georgia were, after 18 months of unclaimed sitting, being cut up and used to replace wooden road marker posts on the base. Only quick action by Roswell Gilpatrick, acting air force secretary, to end the abuse and fix responsibility for it averted another of these full-scale senatorial struggles. Much as such military muddleheadedness hurts, however, it would be civilian muddleheadedness to suppose that it was the reason for our steel shortage. And since two muddleheadednesses don't make one bit of sense, your cooperation in the scrap drive is anything but contraindicated by the hereinbeforementioned snafusion. Scrap scrap or no, don't stop the scrap!

**Man of the hour, day, month, or year**—AWWA has some. What with inflation, though, it pays little attention these days to less than men of major moments—like months, that is. Such a man, certainly, is our old friend Tom Veatch—AWWA ex-prexy and head still of another engineering association called Black & Veatch of KC, Mo. Having warmed up last

*(Continued on page 2)*

(Continued from page 1)

July as "Man of the Week" in the *Kansas City Star*, where he received a page accolade, Tom moved up to "Man of the Month" in the December issue of *Swing*, magazine of Radio Station WHB, Kansas City, with eight pages plus a full-page photo. All this and Betty Grable too (in a bathing suit right at the back of Tom's head) really made us sit up and take notice—to take not just notice, though, pride, too, for Tom's still a water works man no matter who else appreciates him.

Man of even longer than that is almost another Missourian—Charlie Roos of East St. Louis, Ill., who was elected "Man of the Year," by his city's Chamber of Commerce for activity in civic affairs. Credited in his citation with being "either in or on" everything worthwhile going on in his city, Charlie considers his management of the East St. Louis and Interurban Water Co. the most worthwhile of his contributions, even if that didn't count for the award. With him, though, no Betty Grable—just the note that he has a large private collection of fossils of early plant and animal life. But hobby to the contrary notwithstanding, we're proud of Charlie, too, and of East St. Louis for appreciating him.

Last year it was R. B. Simms "of the year" in Spartanburg, S.C. Next year who knows? Anyway, keep your eye on the ball, your nose to the grindstone, your mouth shut, your hands clean, and your feet moving, and maybe someday you, too, will be a man.

**Good news is no news**—so, at least, it must seem to water supply conscious New Yorkers. Belabored in headline, byline and editorial only two years ago during the water shortage, they have developed eyestrain since, hunting for the good word of recent reservoir levels. But now that a chlorine shortage has forced the city to tell Westchester County communities who tap the system en route that they must disinfect their own supplies and now that a knock-down-drag-out fight over future sources of supply is brewing, a new publicity binge seems to be on tap. Misery seems to like publicity almost as much as company. It does seem too bad though that so little good comes of the good winds.

**A hydrant flush that flushed a flush hydrant** was one conducted in Detroit, Mich., one night early in November. Although authorities saw \$490, mostly in \$5 bills, spout out on their very first try, though, they quit right there, not just because they were ahead, but because the teen-age thieves who had secreted the money there assured them that that had been their only investment in water supply. The cash cache splash, however, was only a drop in the bucket—or buckets, for that matter, as the total theft amounted to two suitcases full of bills—the kind of a drop, though, that almost any water works man would flush for. Only, as usual, it was the police department and the fire department that handled the gusher.

(Continued on page 4)

# RUNNING OUT OF GROUND?



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(Continued from page 2)

The U.S. Public Health Service wants several engineers experienced in the water supply field for its water fluoridation program. Anticipating a considerable increase in the number of fluoridated water supplies, the service will need engineers for consultative work at state and local levels. If they wish it and are qualified, applicants may be commissioned, their rank to depend upon experience and training. A degree in engineering (preferably sanitary engineering) and experience in some aspect of water supply design, construction or operation is required. Commissions will be granted up to the Sanitary Engineer grade, which is equivalent to the Navy rank of Lieutenant Commander and offers a salary approximating \$6,381. Additional information and application forms may be obtained from the Surgeon General, U.S. Public Health Service, Washington 25, D.C.

**Charles W. Haydock**, Philadelphia consultant, died on August 31, 1951, at the age of 64. Well known as a water supply engineer, he was a member of the Pennsylvania Registration Board for Professional Engineers and recently prepared a report on Philadelphia's water supply for the local Committee of Fifteen.

(Continued on page 6)

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## M-SCOPE Pipe Finder LIGHTWEIGHT MODEL



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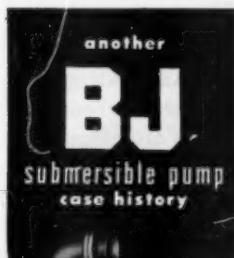
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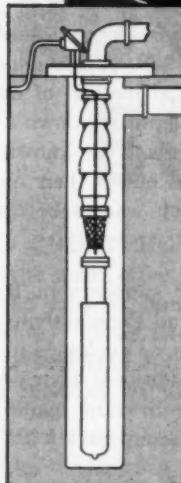
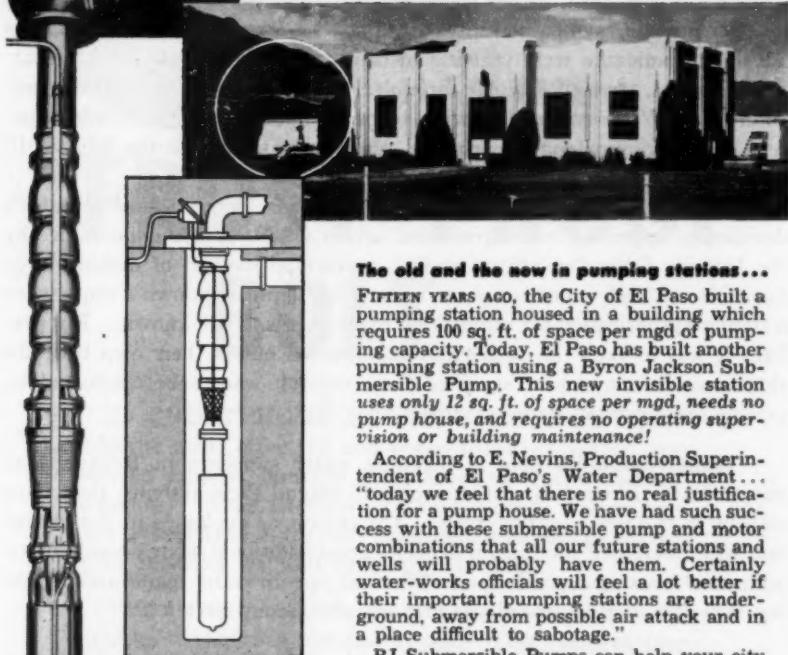
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## El Paso's Invisible Pumping Station saves money, saves maintenance, and safeguards water supply in times of emergency



Installation was achieved by simply sinking a 20 ft. deep, 30" diameter casing, sealed at the bottom with concrete. The 200 hp, 2000 gpm BJ Submersible draws water from the well and discharges to the main. When desired, BJ Submersible Stations can be completely underground, connected only by a power cable.

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FIFTEEN YEARS AGO, the City of El Paso built a pumping station housed in a building which requires 100 sq. ft. of space per mgd of pumping capacity. Today, El Paso has built another pumping station using a Byron Jackson Submersible Pump. This new invisible station uses only 12 sq. ft. of space per mgd, needs no pump house, and requires no operating supervision or building maintenance!

According to E. Nevins, Production Superintendent of El Paso's Water Department... "today we feel that there is no real justification for a pump house. We have had such success with these submersible pump and motor combinations that all our future stations and wells will probably have them. Certainly water-works officials will feel a lot better if their important pumping stations are underground, away from possible air attack and in a place difficult to sabotage."

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(Continued from page 4)

**Maybe rainmaking isn't dead after all** (as a P&R subject, that is), but merely gone underground with the Weather Bureau. And underground is quite literally where the Weather Bureau has gone to test the theories of the cloud seeders—underground in an  $8 \times 8 \times 666$ -ft. deep abandoned zinc mine shaft, where Dr. Ross Gunn, physical research director of the bureau, is manipulating air pressures and live steam to simulate all types of atmospheric conditions. Trust the bureau to pick a spot named Miami as its rainmaking site and, then, almost neglect to point out that it's the Arizonal one.

Meanwhile, sympathetically or otherwise, the elements of Miami's Floridian namesake were reacting to cause what the *Herald*, in its front-page forecast, termed "Dribble Trouble." And a now unsynthetically unsunny New York was endeavoring to prove itself a liar for claiming success in past rainmaking experiments, thereby to save itself the \$2,138,510 price of success (in damage claims).

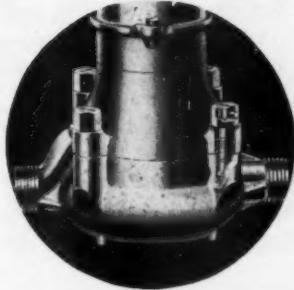
Whether all this had an effect upon the House Interior subcommittee's decision to approve for Congressional action a \$20,000,000 expenditure by the Interior Dept. "on efforts to find a practical method of making large quantities of fresh water out of sea water," while turning down a request for a similar authorization for rainmaking experiments, is not known. But perhaps it was to keep the authorized experiments out of their own bathtubs that committee members specified that research was to be conducted by private organizations under contract.

**Which-came-first-ism** is plaguing water suppliers in Britain these days. Badly in need of cast-iron pipe to extend their systems, they must wait up to two years for deliveries. The reason, as explained to Parliament last July: increased production depends upon additional labor depends upon additional housing depends upon additional pipe for water mains and plumbing depends upon increased production. A viscous circle!

**Amiss is as good as a millennium!** Almost anyway—and Thomas L. Amiss, that is,—for Tom has completed 50 years of service for the citizens of Shreveport, La., in the operation of their water and sewerage utilities—first private, then public. What has happened to Shreveport and what has happened to Tom since he arrived there as a sanitary sewer inspector in November 1901 have been almost synonymous, as might be suggested by the fact that Tom has been superintendent of his department continuously since April 1918 despite the fact that his position is subject to political appointment. That his half-century was well spent may be indicated almost as much by the fact that he has served as a director of and has received the Fuller Award and Honorary Membership from A.W.W.A. as by the fact that his home-town Sunday *Times* spent a half-page of tribute on him on the occasion of his semicentennial.

(Continued on page 8)

# CALMET



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(Continued from page 6)

**Eugene Carroll**, retired general manager of the Butte, Mont., Water Co., died at his home October 3, 1951, at the age of 90. He first became associated with the Butte utility as construction engineer and superintendent in 1891, being promoted to chief engineer three years later. During the company's financial difficulties at the turn of the century he was appointed receiver, and after its reorganization was made general manager, later becoming vice president also. He retired in 1944, after 53 years of service.

**Joseph A. Hayes**, Pennsylvania representative for Neptune Meter Co., died at his home in Camp Hill, Pa., on October 15, 1951. He was 63 years old, and had been with the Neptune organization for more than 30 years.

**J. Arthur Jensen**, AWWA president in 1940, died on October 18, 1951, at the age of 74. From 1914 until his retirement in 1943, he had been superintendent of the Minneapolis Water Works Dept. and guided its rapid growth to meet the city's expanding needs. Among specific construction projects credited to his administration are the Fridley softening and filtration plant and the Columbia Heights filtration plant.

(Continued on page 10)

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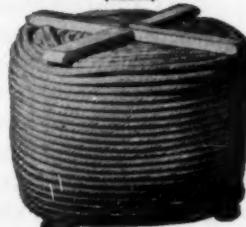
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*(Continued from page 8)*

**George C. Sopp**, head of the Water Meter and Service section of the Los Angeles Dept. of Water & Power, has been appointed to the new post of assistant manager, in which capacity he will be joint system head of Purchasing, Building Operation and Maintenance, Land, Personnel, Salary Standards and Public Relations. He joined the department in 1924 as a laborer in the Water Distribution division. Quickly advanced to water meter and service inspector, he remained in the distribution division through his entire service, being promoted to head the meter and service section in 1940.

**A new plant** to increase the instrument production capacity of Hellige, Inc., is expected to be in operation in February. The plant is located on a 10-acre tract on Stewart Ave., Garden City, N.Y., and will add to the firm's existing facilities in Long Island City and Mineola, N.Y.

**Development** of a new flow measuring device utilizing the differential pressure principle has been announced by George Kent Ltd., Luton, Beds., Great Britain (Canadian branch in Royal Bank Bldg., Toronto 1, Ont.). Known as the Dall Tube, the instrument is said to be smaller and lighter than a short venturi tube producing the same pressure differential, and superior in pressure recovery even to the long venturi.

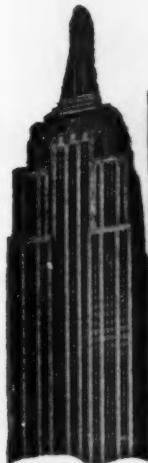
**Allan M. Hirsh**, founder and chairman of the board of the Lock Joint Pipe Co. of East Orange, N.J., died on Dec. 21, 1951, at the age of 73. He had been president of the firm from its establishment in 1905 until last year, when he became chairman of the board.

Hirsh turned to the manufacture of reinforced concrete pressure pipe after an earlier, unsuccessful venture with cement cylinders intended to serve as dock pilings. In addition to his prominence in business life, he was noted as the author of words and music of Yale University's famous "Bool-a-Bool-a" song.

**The California plant** of U.S. Pipe and Foundry Co., located at Decoto in Alameda County, began in early November the first production of centrifugally cast pipe in any of the Pacific Coast states. The plant, which employs 125 men, has three casting machines, a pipe annealing oven, two core blowing machines, and a core oven. Storage facilities for raw materials—pig iron, coke, and limestone—are provided, as well as equipment for subjecting pipe to hydrostatic tests, drilling mechanical joints, painting and lining equipment, and similar processes. At present, pipe production will be limited to the 4-to 12-in. size; however, facilities have been included to permit expanded production in the future.

*(Continued on page 12)*

# Many are the reasons why Smith hydrants are used by America's leading cities!



Empire State  
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New York — Philadelphia — Washington — Baltimore — St. Louis — Providence and scores of other cities throughout the nation use SMITH hydrants — and not without good reason. A few of these reasons can easily be seen upon inspection of the hydrant section shown at the left.

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- 2 Frangible couplings for collision protection.
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- 4 Tapered, frost-proof barrel.
- 5 Compression-type valve.
- 6 Positive action drain—always closed when main valve is open.

31

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ESTABLISHED 1894  
EAST ORANGE, NEW JERSEY

*(Continued from page 10)*



Robert B. Diemer



Julian Hinds

**Robert B. Diemer** has succeeded Julian Hinds as general manager and chief engineer of the Metropolitan Water Dist. of Southern California, upon the latter's retirement the last day of 1951. A civil engineering graduate of the University of Missouri, Diemer began his engineering career with the U.S. Reclamation Service, and from 1911 to 1926 worked on dam and irrigation projects in Nebraska and Wyoming. Later he joined a private construction agency performing similar work for the Mexican government, and in 1929 he joined the Metropolitan district to work on preliminary engineering studies for the Colorado River aqueduct. In 1941 he became chief operation and maintenance engineer for the district, and in 1950 was appointed assistant general manager and chief engineer.

Julian Hinds, who now ends more than 20 fruitful years of service to the area served by the utility, was one of the first members of the engineering staff who designed and built the \$200,000,000 aqueduct that now delivers Colorado River water to the 44 member cities in the 1,500 square mile area. A graduate of Texas University, he has been an active engineer for 42 years and is a recognized authority on the design and construction of dams.

**Peter C. Reilly**, founder and president of Reilly Tar & Chemical Corp., Indianapolis, died on January 4 at the age of 83. He had devoted a lifetime of endeavor to the coal-tar industry, beginning in 1886, when he joined the Mica Roofing Co. of New York, one of the early coal tar distillers. In 1900 he organized his own firm, the Western Chemical Co., which, after subsequent reorganization and consolidation developed into a branch of the present Reilly Tar & Chemical Corp.

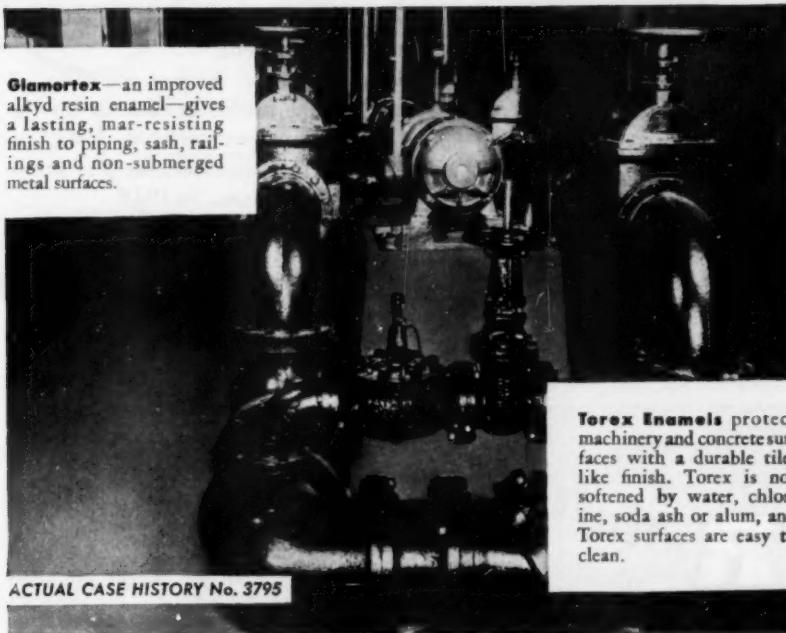
*(Continued on page 14)*

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(Continued from page 12)



**Eugene F. Dugger**, who retired as general manager of the Newport News, Va., Water Works Commission because of extended ill health only a month previously, died on December 29, 1951, at the age of 53.

He had guided the commission's affairs since 1926, when it was created, and for seven years before that had been associated with the predecessor Newport News Water & Light Co. as assistant superintendent.

In addition to being a past-president of AWWA (1938), he served as director for the Virginia Section and received, in 1943, its

Fuller Award. He had helped to organize the section when he was president of the Virginia Water Works and Sewerage Assn., in 1933.

As head of the Newport News water utility, he saw it double its value in 25 years, as expansions were mapped to parallel the community's growth. In addition to his service as utility head, he was active in local civic and religious organizations, and was president of the Chamber of Commerce.

(Continued on page 16)

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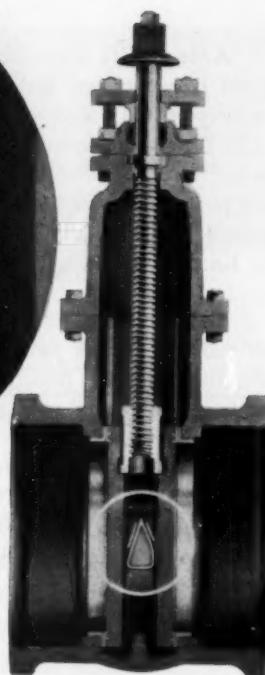
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The gate on this side is pulled first. This quickly releases wedging pressure on both gates.

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9. Interchangeable parts — due to precision Casting and Machining.
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*(Continued from page 14)*

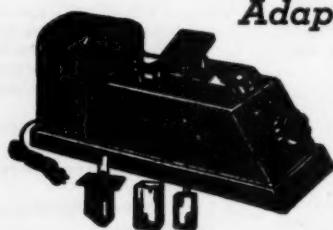
**A dog's life** these days is really a dog's life. Just when our canine world of suburban Kansas City has redeveloped its taste for stuffed trouserseat and flapping pantleg after a long, hard wartime fast, what does L. S. McArthur, general manager of the Kansas City Suburban Water Co., do but hire five women water meter readers—with slacks. Grrrr! Not just poorer bite and less of it, but now every bark and snap draws a moan instead of a bone from the mistress. Where does a mutt sign up, anyway, for Kanines for Korea, now that MacArthur's out of there?

**Talk about good intentions**, the streets of Laguna Beach, Calif., are hot too, but they're paved these days with flowering geraniums. At any rate when the water department had to leave a main excavation unpaved after refilling, it appeared next morning covered with some 53 geraniums neatly planted down the middle of a busy street. In less balmy climes, on the other hand, intentions don't come off so well. A small hole in the pavement of a street in New York City, for instance, recently cost \$100,000—the amount of settlement of a \$500,000 suit brought by a construction worker who had been thrown out of a truck which legally failed to encounter paving where the hole was. So it goes—one man sows and another reaps!

*(Continued on page 18)*

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PEKRUL GATE DIVISION

# MORSE

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DENVER, COLORADO

Write for Catalog 49

(Continued from page 16)

**To stop the show** is no mean accomplishment in the world of the theatre. To stop the show before it even gets started, however, is mean, so it cannot be considered to the credit of water that the November 26 performance of George Bernard Shaw's *Saint Joan*, starring Uta Hagen, was stopped to the point of cancellation. Water it was, though, that caused the calamity—water in the hydraulic system which operates the asbestos curtain. And having kept a full house in its seats for a full forty minutes, water missed its cue and let the audience down.

Meanwhile, up in Alberta, water in another form stops another form of show, merely by stopping showing. Thus, although it provides an 8-billion-gal supply each year to the Calgary Power Co., the Ghost River lives up to its name by flowing visibly only fitfully. Now you see it, now you don't, depending upon the level of the water table in the gravel through which it flows and depending upon where in the gravel bed of several hundred yards width you happen to look for it.

All this water, though, is no more ornery than it is ordinary. If the show must go on, water's always in there pitchering.

**The super-Hooper rating**, whereby the intensity of radio listening can be determined by the drop in water use during a program and its sharp rise above normal immediately after it, has now been applied to television—*Sparling Metrograms* reporting Chicago's meter chart record of the Ezzard Charles-Joey Maxim fight. For a fight, we'll agree the rating is applicable; but for a regular TV program, we have our doubts. On the same page as the fight report, the Sparling bulletin points out that "a dime is a dollar with the taxes removed." Even more pertinently it could have indicated that, on TV, ten minutes is an hour with the commercials removed. And the content of those commercials may make people want to indulge, rather than attempt to suppress, the desire to use water during TV hours—and not for drinking either.

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**Cask Force**

*To the Editor:*

I have recently read with interest and amusement the "Percolation and Runoff" comments of October (P&R p. 1) and November 1950 (p. 20) concerning the mysterious self-filling water barrel in southern Missouri. I had been wondering for some time what attitude the AWWA and others in the field might have taken toward it. Prior to this date the only national water works official I had asked for an opinion from was Dr. Weir, the then president, who simply said it was in his casual opinion being filled in some natural way or through some hoax.

At the present time I am preparing a complete and detailed paper on the phenomenon for the *Journal of the American Society for Psychical Research*, and for use in this paper I should like to have your own opinion about it. Dr. Weir's opinion just about covers completely the possible explanations, boiled down to their essentials—except the supernatural, of course. As I am in search of the correct explanation from an unbiased point of view, I have to date had to fall back on the supernatural for the simple reason that I have completely failed in an intensive effort to find some natural function of nature which—however freakish or unique—might fit in with the conditions and data gathered at the barrel. It goes without saying that I am firmly convinced that no hoax was involved: it occurred

*(Continued on page 84)*

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**Municipal Accounting and Auditing.** *National Committee on Governmental Accounting, 1313 E. 60 St., Chicago 37, Ill. (1951) \$4.*

This volume, sponsored by the Municipal Finance Officers Assn., constitutes a revision of four previous publications: "Municipal Accounting Statements," "Municipal Funds and Their Balance Sheets," "Municipal Accounting Terminology," and "Municipal Audit Procedure." Among revisions embodied in the new publication are a clearer recognition of the responsibility of financial systems to accord with both law and sound financial procedure; the distinction between accrual and modified accrual bases; and the inclusion of other self-supporting enterprises with water and other utilities.

**Environment and Health.** *Pub. 84, Public Health Service, Federal Security Agency, Washington, D.C. (1951) 75¢ from Supt. of Documents, Government Printing Office, Washington 25, D.C.*

This 152-page, paperbound book places drinking water in perspective as but one aspect of the broad field of environmental control for the improvement of public health. Emphasis is placed upon control of disease and pollution, with particular emphasis upon the role of the Public Health Service. Other chapters discuss air pollution, milk and food sanitation, pest control, industrial health, radiology, administration, and similar topics.

**The Miami Conservancy District.** *Arthur E. Morgan. McGraw-Hill Book Co., Inc., New York (1951) \$6.50*

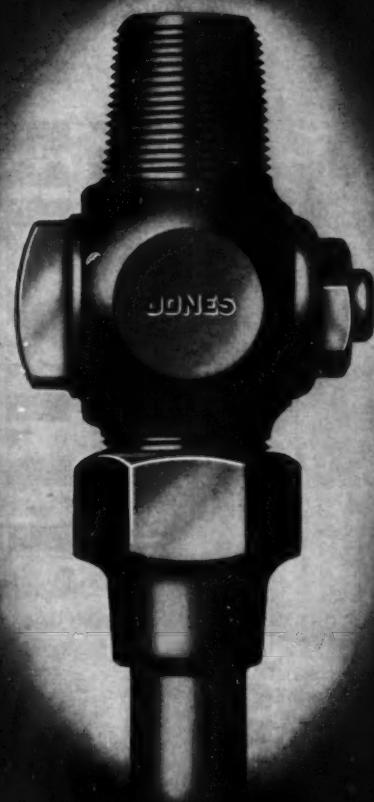
Arthur Morgan's "The Miami Conservancy District" is required reading for engineers who concern themselves with water resources and flood control. This book tells the story of the 1913 flood which spread devastation across Ohio and Indiana and nearly destroyed the industrial city of Dayton, Ohio. Before the water had fully subsided, leaders of the community began to plan what to do to protect themselves against the next deluge. Those were the days when a city or a region did its own planning and even spending for flood control works. It makes wholesome reading therefore, in 1952, to

*(Continued on page 60)*

Jan. 1952

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<p><b>METCALF &amp; EDDY</b> <b>Engineers</b></p> <p>Water, Sewage, Drainage, Refuse and Industrial Wastes Problems Airfields Valuations Laboratory</p> <p>Statler Building Boston 16</p>	<p><b>THOMAS M. RIDDICK</b> <b>Consulting Engineer and Chemist</b></p> <p>Municipal and Industrial Water Purification, Sewage Treatment, Plant Supervision, Industrial Waste Treatment, Laboratories for Chemical and Bacteriological Analyses</p> <p>369 E. 149th St. New York 55, N.Y.</p>
<p><b>THE H. C. NUTTING COMPANY</b> <b>Engineers</b></p> <p>Water Distribution Studies Water Waste Surveys Trunk Main Surveys Meter and Fire Flow Test</p> <p>4120 Airport Road Cincinnati 26, Ohio</p>	<p><b>RIPLE &amp; HOWE</b> <b>Consulting Engineers</b></p> <p>O. J. RIPLE B. V. HOWE Appraisals—Reports Design—Supervision</p> <p>Water Works Systems, Filtration and Softening Plants, Reservoirs, and Dams, Sanitary and Storm Sewers, Sewage Treatment Plants, Refuse Disposal, Airports</p> <p>426 Cooper Bldg., Denver 2, Colo.</p>

<p><b>NICHOLAS A. ROSE</b>  <i>Consulting Ground Water Geologist</i></p> <p>Investigations      Reports      Advisory Service</p> <p>1309 Anita Ave. Houston 4, Tex.</p>	<p><b>Professional Services</b>      (contd.)</p>						
<p><b>RUSSELL &amp; AXON</b>  <i>Consulting Engineers</i></p> <p>GEO. S. RUSSELL F. E. WENGER      JOE WILLIAMSON, JR.</p> <p>Water Works, Sewerage, Sewage Disposal,      Industrial and Power Plants, Appraisals</p> <p>408 Olive St. Municipal Airport      St. Louis 2, Mo. Daytona Beach, Fla.</p>	<p><b>ALDEN E. STILSON &amp; ASSOCIATES</b>  <i>Limited</i>  <i>Consulting Engineers</i></p> <table border="0"> <tr> <td>Water Supply</td> <td>Sewerage</td> <td>Waste Disposal</td> </tr> <tr> <td>Mechanical</td> <td></td> <td>Structural</td> </tr> </table> <p>Surveys Reports Appraisals</p> <p>209 South High St. Columbus, Ohio</p>	Water Supply	Sewerage	Waste Disposal	Mechanical		Structural
Water Supply	Sewerage	Waste Disposal					
Mechanical		Structural					
<p><b>SAMUEL SHENKER</b>  <i>Chemical Consultant</i></p> <p>Water Treatment      Laboratory Service</p> <p>—</p> <p>155 S. Broadleigh Rd., Columbus 9, Ohio</p>	<p><b>WESTON &amp; SAMPSON</b>  <i>Consulting Engineers</i></p> <p>Water Supply and Purification; Sewerage,      Sewage and Industrial Waste Treatment,      Reports, Design, Supervision of Construc-      tion and Operation; Valuations.      Chemical and Bacteriological Analyses</p> <p>14 Beacon Street Boston 8, Mass.</p>						
<p><b>J. E. SIRRINE COMPANY</b>  <i>Engineers</i></p> <p>Water Supply &amp; Purification,      Sewage &amp; Industrial Waste Disposal,      Stream Pollution Reports,      Utilities, Analyses</p> <p>Greenville South Carolina</p>	<p><b>WHITE, GUYTON &amp; BARNES</b>  <i>Consulting Ground-Water Hydrologists</i></p> <p>GROUND-WATER SUPPLIES</p> <p>Evaluation; Planning of New Developments;      Operational and Maintenance Advice; Legal      Proceedings; Artificial Recharge, Induced River      Infiltration, Well Interference and Other      Ground-Water Problems.</p> <p>307 W. 12th St. Austin 1, Texas</p> <p>Tel. 7-7165</p>						
<p><b>SMITH AND GILLESPIE</b>  <i>Consulting Engineers</i></p> <p>Water Supply and Treatment Plants;      Sewerage, Sewage Treatment; Utilities;      Zoning; Reports, Design, Supervision of      Construction and Operation; Appraisals.</p> <p>P.O. Box 1048 Jacksonville, Fla.</p>	<p><b>WHITMAN &amp; HOWARD</b>  <i>Engineers</i>      (Est. 1869.)</p> <p>Investigations, Designs, Estimates,      Reports and Supervision, Valuations,      etc., in all Water Works and Sewerage      Problems</p> <p>89 Broad St. Boston, Mass.</p>						
<p><b>STANLEY ENGINEERING COMPANY</b></p> <p>Waterworks—Sewerage      Drainage—Flood Control      Airports—Electric Power</p> <p>—</p> <p>Hershey Building      Muscatine, Ia.</p>	<p><b>WHITMAN, REQUARDT &amp; ASSOCIATES</b>  <i>Engineers Consultants</i></p> <p>Civil—Sanitary—Structural      Mechanical—Electrical      Reports, Plans,      Supervision, Appraisals</p> <p>1304 St. Paul St. Baltimore 2, Md.</p>						

## Membership Changes



### NEW MEMBERS

*Applications received November 1 to November 30, 1951*

**Anderson, Leonard Meade**, Water Operator, Water Dept., 12340 N.E. 8th Ave., North Miami, Fla. (Oct. '51) *P*

**Arismendi, Carmelo**, Water Supt., Departamento de Operacion, Instituto Nacional de Obras Sanitarias, Caracas, Venezuela (Oct. '51) *MP*

**Badley, Willis Harry**, Salesman, Neptune Meter Co., 640 Highland, Salina, Kan. (Oct. '51) *MR*

**Ball, Henry F., Jr.**, City Engr., Director of Public Works, Paris, Tex. (Oct. '51)

**Barnes, James**, Water Comr., Calexico, Calif. (Oct. '51) *MP*

**Billmire, Garrett O.**, Asst. Chief Engr., Field Div., State Dept. of Public Improvements, 506 Park Ave., Baltimore, Md. (Oct. '51)

**Blois, Robert W.**, Repr., Johns-Manville Sales Corp., Box 28, Phoenix, Ariz. (Oct. '51) *MR*

**Boughton, Roger C.**, *see* Utility Clamp & Equipment Co.

**Brayton, John C.**, *see* Utica (N.Y.) Board of Water Supply

**Bretz, Bartlett G.**, Sales Repr., U.S. Pipe & Foundry Co., 5109 W. 71st St., Mission, Kan. (Oct. '51) *MR*

**Brockenbrough, Austin, Jr.**, Cons. Engr., Perron & Brockenbrough, 1900 W. Broad St., Richmond, Va. (Oct. '51)

**Bullard, George Styles**, Water Plant Operator, Water Dept., 12340 N.E. 8th Ave., North Miami, Fla. (Oct. '51)

**Burton Township Water Dept.**, Donald MacDonald, Pres., 2031 E. Bristol Rd., Flint 7, Mich. (Mun. Sv. Sub. Oct. '51)

**Cantlin, Richard**, Supt., Water Distr. Water Dept., City Hall, Port Huron Mich. (Oct. '51)

**Carlson, Carl Herman**, San. Engr., USAF, Air Installation Section, Headquarters, Central Air Defense Force, Box 528, Kansas City 6, Mo. (Jr. M. Oct. '51) *P*

**Cherry, Arnold K.**, Chief Chemist, Water Works, Cedar Rapids, Iowa (Oct. '51) *P*

**Clark, Bill C.**, Water Supt., Galveston County Water Control & Improvement Dist. No. 3, 224 Bayou Road, La Marque, Tex. (Oct. '51)

**Coates, Benjamin N.**, Plant Supt., Water Works, Cedar Rapids, Iowa (Oct. '51)

**Colby, City of**, Gerald G. Hartman, City Mgr., City Hall, Colby, Kan. (Corp. M. Oct. '51) *MR*

**Corbit, F. E.**, Supt. of Distr., Water Dept., Carbondale, Ill. (Oct. '51) *M*

**Cotten, Whitworth**, City Engr., City Hall, Petersburg, Va. (Oct. '51) *P*

**Cridland, R. W.**, Vice-Pres., Varner Well Drilling Co., Inc., 905 American Trust Bldg., Dubuque, Iowa (Oct. '51) *M*

**Curto, John P.**, Gen. Foreman, Services & Meters, Water Dept., 425 Mason St., San Francisco, Calif. (Oct. '51) *M*

**Dahl, Arve H.**, Chief, San. Section, Div. of Medical & Health Services, State Office of Civil Defense, 760 Market St., San Francisco, Calif. (Oct. '51) *MPR*

**Duggan, Maury L.**, Dist. Mgr., Mathieson Chem. Corp., 225 Chester Ave., S.E., Atlanta, Ga. (Oct. '51)

**Dunlap, Forrest J.**, Lassen County Works Dist. No. 1, Box 8, Bieber, Calif. (Oct. '51) *P*

**Elizabethtown Water Co. Consolidated**, Robert R. Stone, Supt. & Engr., 22 W. Jersey St., Elizabeth, N.J. (Corp. M. Oct. '51)

**Ellis, Roger G.**, Engr.-Gen. Mgr., Diablo Water Co., 1121 Apple Point, Concord, Calif. (Oct. '51) *MPR*

**Evans, William F., Jr.**, San. Engr., Design Section, Public Works, Camp Lejeune, N.C. (Oct. '51) *R*

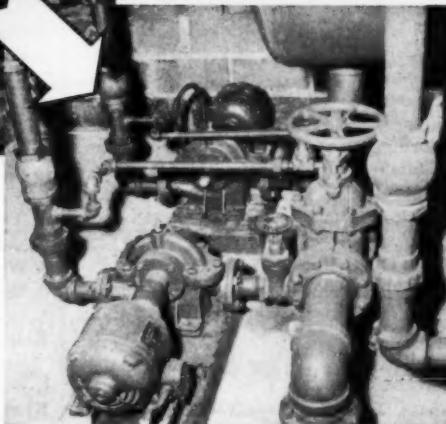
(Continued on page 32)

# NEW DELAVAL GS PUMPS

## on their way to you in



2  
WEEKS



*from our shelf  
to your plant  
in two weeks!*

That's how fast you can get  
a standard centrifugal  
De Laval pump.

We now have on hand GS pumps, motors and bedplates in sizes  $2\frac{1}{2}$ ", 3" and 4" ready for assembly and shipment. Capacities to 280 gpm, heads to 75 ft, at 1750 rpm. • Also available for immediate delivery are bare pumps in the same sizes with capacities to 400 gpm, heads to 230 ft, at 3500 rpm. We can assemble and ship these units within two weeks after receipt of the motor.



*Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY  
TRENTON 2, NEW JERSEY

DL1Q3A

(Continued from page 30)

**Ferguson, D. L.**, Secy-Treas. & Gen. Mgr., The Cave Spring Water Co., Inc., Route 4, Box 84, Roanoke, Va. (Oct. '51) *M*

**Flood, John Hebard, Jr.**, San. Engr., Reynolds, Smith & Hills, 227 Park St., Jacksonville, Fla. (Oct. '51) *PR*

**Ford, M. E., Jr.**, *see* Yorba Linda (Calif.) Water Co.

**Fortier, H. J.**, *see* Foster Engineering Co.

**Foster Engineering Co.**, H. J. Fortier, Vice-Pres. in charge of Sales, 835 Lehigh Ave., Union, N.J. (Assoc. M. Oct. '51)

**Freeland, A. R.**, Asst. Water Supt., City Hall, Sierra Madre, Calif. (Oct. '51) *MPR*

**Fresno County Water Works—Dist. IV**, Harvey H. Shields, Exec. Mgr., 216 Brix Bldg., Fresno, Calif. (Corp. M. Oct. '51) *MPR*

**Furrey, William P.**, Chairman, North Jersey Dist. Water Supply Com., Wanaque, N.J. (Oct. '51) *MR*

**Gartner, George C.**, Secy., Varner Well Drilling Co., Inc., 2090 Simpson St., Dubuque, Iowa (Oct. '51) *M*

**Gibbs, William Read**, Civ. Engr., Black & Veatch, 4706 Broadway, Kansas City 2, Mo. (Oct. '51) *R*

**Glad, Albert R.**, *see* Tulare (Calif.)

**Grapier, Norman H.**, Supt., Water Works, 419 Madison Ave., Los Banos, Calif. (Oct. '51) *M*

**Grenier, J. L. V.**, *see* Lafourche Parish Water Dist. No. 1

**Gross, John W.**, Repr., *Water & Sewage Works*, 22 W. Maple St., Chicago 60, Ill. (Oct. '51) *MPR*

**Gutierrez, Alberto**, Engr., Comision de Fomento Nacional, Havana, Cuba (Oct. '51) *R*

**Hall, Ralph H.**, Engr., Vinson Specialty Paint Co., 522 W. Adams St., Jacksonville, Fla. (Oct. '51)

**Harman, Harry D.**, Supt. of Operations & Constr., Gary-Hobart Water Corp., 545 Broadway, Gary, Ind. (Oct. '51) *M*

**Harris, John William**, Supt., Public Utility Dist., 605 Central Valley Highway, Shafter, Calif. (Oct. '51) *MR*

**Hartman, Gerald G.**, *see* Colby (Kan.)

**Hayes, R. J.**, City Mgr., Augusta, Kan. (Oct. '51) *P*

**Head, James W., Jr.**, Director of Public Utilities, City Hall, Falls Church, Va. (Oct. '51) *M*

**Henry, William Marvin**, Chief Alum Plant Operator, Water Purification Div., Washington Dist., Corps of Engrs. 5900 MacArthur Blvd., N.W., Washington 16, D.C. (Oct. '51) *P*

**Herring, D. J.**, Water Supt., Water Dept., City Hall, Parlier, Calif. (Oct. '51) *M*

**Holzie, Harry R.**, San. Engr., State Board of Health, Courthouse, Dodge City, Kan. (Oct. '51) *P*

**Hook, Darwin Dewey**, Sales Engr., Layne-Western Co., 1011 Wheeler St., Wichita, Kan. (Oct. '51) *R*

**Jewell, K. Austin**, Hydr. Engr., Koppers Co., 109 N. Wabash Ave., Chicago, Ill. (Oct. '51) *MPR*

**Johnson, Dale Morris**, Chemist, Munic. Purif. Plant, 528 N. Erie, Wichita, Kan. (Oct. '51)

**Johnson, Owen C.**, Mgr., Dunsmuir Water Corp., Dunsmuir, Calif. (Oct. '51) *M*

**Johnston, Robert M.**, Cons. Chemist-Bacteriologist, Robert M. Johnston & Assoc., 504 N. 2nd St., Harrisburg, Pa. (Oct. '51) *P*

**Jones, Walter B.**, Engr., Hetch Hetchy Water Supply, San Francisco Water Dept., 425 Mason St., San Francisco 1, Calif. (Oct. '51) *R*

**Kelly, Eugene R.**, Dist. Public Health Engr., State Board of Health, Rhinelander, Wis. (Affil. M. Oct. '51) *MPR*

**Kemper, A. J.**, Distributor, The Permutit Co., Box 1201, Bradenton, Fla. (Oct. '51)

**King, Thomas**, Asst. Mgr., Water Works, Box 1600, Columbus, Ga. (Oct. '51)

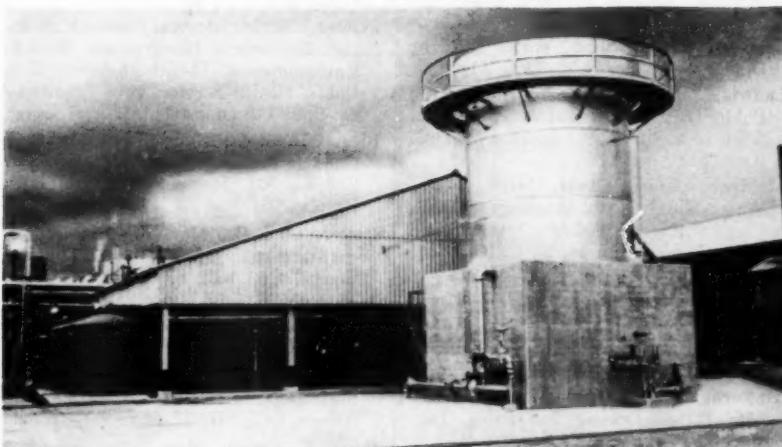
**Kistler, John L.**, Supt., Water Works, 268 Main St., Watsonville, Calif. (Oct. '51) *P*

**Lafourche Parish Water Dist. No. 1**, J. L. V. Grenier, Pres., Thibodaux, La. (Corp. M. Oct. '51) *MPR*

**Lauderdale, Richard L.**, Sales Engr., Builders-Providence, Inc., 1036 University Ave., Berkeley, Calif. (Oct. '51) *P*

**Laughlin, Chandler A.**, Asst. Engr., Pacific Gas & Electric Co., 245 Market St., San Francisco, Calif. (Oct. '51)

(Continued on page 34)



SPECIALLY DESIGNED 500 GPM WORTHINGTON TREATING SYSTEM at the new Pemex natural gas refinery in Poza Rica, Mexico. System includes cold-process slurry-type softener followed by acid feed, filtration and zeolite treatment. Engineered by Arthur G. McKee Company.

## Specially Designed for Intermittent Service

*Softening system for boiler feed water built for  
short-period operation, long shutdowns*

Water conditioning requirements are especially tough at the new Pemex natural gas refinery in Poza Rica, Mexico.

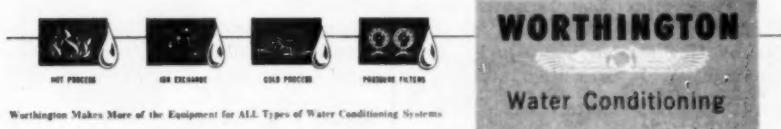
Their need for variable-rate, continuous-service softener operation is complicated by the intermittent boiler feed-water storage demands.

Pemex's conditioning requirements have been met by a specially built Worthington system, so designed that the slurry bed is not lost during "off-service" periods. The bed resumes its normal suspended position at the instant service is resumed. This avoids the irregular treatment, delay and water waste common in systems that require

creation of a new slurry bed after each shutdown period.

New Bulletin W-212-B5 gives you the vital facts about this unique cold process water softening method. Write for your free copy today.

Worthington engineers and builds equipment for all the major types of water-conditioning systems, therefore is in an excellent position to give comprehensive and well-balanced recommendations on your water-conditioning equipment problems . . . further proof that *there's more worth in Worthington*. Worthington Pump and Machinery Corporation, Water Treating Section, Harrison, N. J.



Worthington Makes More of the Equipment for ALL Types of Water Conditioning Systems

(Continued from page 32)

**Lee, Roger Dale**, Dist. San. Engr., Div. of San., State Board of Health, 403 E. William, Wichita 2, Kan. (Oct. '51) *MPR*

**Leiper, Fred M.**, Supt., Water & Light Dept., Wellsville, N.Y. (Oct. '51)

**Ludwig, John H.**, Sr. San. Engr., U.S. Public Health Service, 3613 Federal Security Bldg., N., Washington 25, D.C. (Oct. '51) *R*

**Lundberg, John Albert**, Mech. Engr., Water Supply Div., Washington Dist., Corps of Engrs., 5900 MacArthur Blvd., N.W., Washington 16, D. C. (Oct. '51) *M*

**MacDonald, Donald**, *see* Burton Township Water Dept.

**Massey, Harry H.**, Supt. of Utilities, Humboldt, Kan. (Oct. '51) *MPR*

**Mattern, James L.**, Sales Repr., Dresser Mfg. Div., Dresser Industries, Inc., Bradford, Pa. (Oct. '51) *M*

**McGuire, A. D.**, Asst. Secy., Kansas Association of Munic. Utilities, Box 99, Overland Park, Kan. (Oct. '51)

**Miller, Earl P.**, Chemist, Tech. Service & Market Development, Stauffer Chem. Co., 824 Wilshire Blvd., Los Angeles 14, Calif. (Oct. '51) *P*

**Miller, Frank B.**, Repr., Mueller Co., 729 Penman Rd., Jacksonville, Fla. (Oct. '51)

**Miller, Harold E.**, Exec. Officer, Water Pollution Control Board, San Diego Region No. 9, 3441 University Ave., San Diego 4, Calif. (Oct. '51) *P*

**Mockett, Phil**, Mgr., Western Supply Co., 820 N. St., Lincoln, Neb. (Oct. '51)

**Nance, John E.**, Clerk & City Mgr., Box 324, Hatch, N.M. (Oct. '51) *M*

**Neprud, Herbert L.**, Munic. Utility Supt., Electric & Water Utility, 104—1st St., Westby, Wis. (Oct. '51) *M*

**Neumann, Harry George Charles**, Research Microbiologist, Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '51) *P*

**Newby, G. C.**, *see* Sterling (Kan.)

**Newman, W. J.**, Sales Engr., Wallace & Tiernan Co., Inc., Box 178, Newark 1, N.J. (Oct. '51) *P*

**Nordby, Robert C.**, San. Engr., Bureau of Yards & Docks, U.S. Navy, Washington 25, D.C. (Oct. '51) *P*

**O'Day, Cecil M.**, Supt. of Constr. & Distr., Water Works, Cedar Rapids, Iowa (Oct. '51) *M*

**Palmer, Charles Mervin**, Research Biologist, Research & Development Branch, Environmental Health Center, U.S. Public Health Service, 1014 Broadway Cincinnati 2, Ohio (Oct. '51) *P*

**Pigg, Wilfred L.**, Mgr., Commonfields of Cahokia Public Water Dist., 705 Upper Cahokia Rd., Route 1, East St. Louis, Ill. (Oct. '51)

**Porter, Clell O.**, Mgr., Coating & Reconditioning Div., Pacific Pipeline Constr. Co., 1632 S. Greenwood Ave., Montebello, Calif. (Oct. '51) *M*

**Rawding, Harry LeRoy**, Water & Sewer Comr., Smith Center, Kan. (Oct. '51)

**Rodger, William Allen**, Asst. Dist. Engr., State Dept. of Health, 6½ S. Court St., Athens, Ohio (Jr. M. Oct. '51) *MPR*

**Rose, R. Burton**, Cons. Geologist, Box 583, San Jose, Calif. (Oct. '51) *R*

**Rosenberry, Don**, City Supt., Meade, Kan. (Oct. '51) *MR*

**Russell, Frank A.**, 1656 Illinois St., Lawrence, Kan. (Oct. '51)

**Scheidel, Arthur F.**, Vice-Pres. & Mgr., Culligan Soft Water Service, 721 S. Front St., Mankato, Minn. (Oct. '51) *P*

**Schell, Arthur W.**, Water Office Mgr., Water Dept., City Hall, Port Huron, Mich. (Oct. '51) *M*

**Seegmueler, Elmer Louis**, Dist. Engr., State Board of Health, Box 634, Hays, Kan. (Oct. '51) *M*

**Setterstrom, Richard C.**, Indus. Engr., The Montana Power Co., Butte, Mont. (Oct. '51) *MR*

**Shields, Harvey H.**, *see* Fresno County Water Works—Dist. IV

**Shoemaker, Jesse Ralph**, Cons. Hydr. Engr., Box 66, San Dimas, Calif. (Oct. '51) *R*

**Silman, Maurice J.**, Pres., Outpost Estates, Palm Springs Outpost Water Co., Box 1312, Palm Springs, Calif. (Oct. '51) *MPR*

**Silvey, J. K. Gwynn**, Chairman, Div. of Science, North Texas State College, Box 5183 North Texas Station, Denton, Tex. (Oct. '51) *P*

(Continued on page 36)

# 1879—ROSS—1879

## Automatic Valves



ALTITUDE VALVE

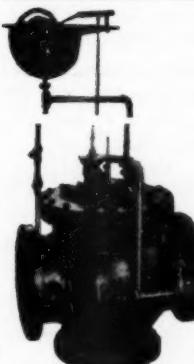
Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting



REDUCING VALVE

Maintains desired discharge pressure regardless of change in rate of flow



FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

Maintains safe operating pressures for conduits, distribution and pump discharge



SURGE-RELIEF VALVE

A self contained unit with three or more automatic controls



COMBINATION VALVE

Combination automatic control both directions through the valve.



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

*Packing Replacements for all Ross Valves Through Top of Valve*

**ROSS VALVE MFG. CO., INC., P. O. BOX 593, TROY, N. Y.**

(Continued from page 34)

**Simpson, Robert M.**, Owner, Calwa City Water Co., Box 128, Fresno, Calif. (Oct. '51) *M*

**Snary, Frank**, Frank Snary Co., 7150 N.W. 5th Pl., Miami 38, Fla. (Oct. '51) *P*

**Sterling, City of**, G. C. Newby, City Clerk, City Bldg., Sterling, Kan. (Corp. M. Oct. '51) *MR*

**Stich, Frank G.**, Salesman, Badger Meter Mfg. Co., 2371 N. 30th St., Milwaukee, Wis. (Oct. '51)

**Stickel, John Frederick, Jr.**, Engr. in charge of Geophysical Services, Dames & Moore, 816 W. 5th St., Los Angeles, Calif. (Oct. '51) *R*

**Stone, Robert T.**, *see* Elizabethtown Water Co. Consolidated

**Tarlton, Morris**, Chemist, Board of Light & Water Comrs., Concord, N.C. (Jr. M. Oct. '51) *P*

**Thompson, Hugh L.**, Office Mgr., Spinks Water Service, 3606 El Camino Real, Palo Alto, Calif. (Oct. '51) *MR*

**Townsend, Rex L.**, Salesman, Johns-Manville Sales Corp., Box 2236, Lakeland, Fla. (Oct. '51)

**Tresch, Albert H.**, Supt., North Marin County Water Dist., Box 357, Novato, Calif. (Oct. '51) *P*

**Tulare, City of**, Albert R. Glad, Office Mgr., City Hall, Tulare, Calif. (Corp. M. Oct. '51) *MPR*

**Utica Board of Water Supply**, John C. Brayton, Gen. Mgr., 712 Washington St., Utica, N.Y. (Mun. Sv. Sub. Oct. '51)

**Utility Clamp & Equipment Co.**, Roger C. Boughton, Pres., Box 3461 Terminal Annex, Los Angeles 54, Calif. (Assoc. M. Oct. '51)

**Wagner, Robert Richard**, Office Mgr., Indio Water Service, Indio, Calif. (Oct. '51) *M*

**Weaver, Joseph**, Mgr., Penns Grove Water Supply Co., 76 E. Main St., Penns Grove, N.J. (Oct. '51) *M*

**Weber, R.**, Supt., Water Dept., Winter Haven, Fla. (Oct. '51)

**Westerlage, George**, Water Supt., Galveston County Water Control & Improvement Dist. No. 3, 224 Bayou Rd., La Marque, Tex. (Oct. '51)

**Wickwire, Dwight S.**, Supt., Water Dept., Yarmouth, N.S. (Oct. '51)

**Wilson, B. N.**, Secy.-Treas., Briley, Wild & Assocs., Box 3052, Daytona Beach, Fla. (Oct. '51)

**Winkler, H. D.**, Water Supt., Galveston County Water Control & Improvement Dist. No. 1, Dickenson, Tex. (Oct. '51)

**Wood, John R.**, Supt., Water Dept., The Pacific Lumber Co., Scotia, Calif. (Oct. '51) *P*

**Yorba Linda Water Co.**, M. E. Ford, Jr., Supt., Box 8, Yorba Linda, Calif. (Corp. M. Oct. '51) *MR*

## REINSTATEMENT

**McLaughlin, Maurice M.**, Comptroller, North Jersey Dist. Water Supply Com., Wanaque, N.J. (Oct. '41) *MR*

## LOSSES

### Deaths

**Carroll, Eugene**, 315 E. Granite St., Butte, Mont. (June '04) *Director '30-'31*  
*Fuller Award '43*

**Jensen, J. Arthur**, 2400 Harriet Ave., Minneapolis 5, Minn. (Apr. '10) *Trustee '25-'27*, *Director '31-'33, '40-'41*, *President '40*. *M*

**McLaughlin, Carroll W.**, Civ. Engr. & Surveyor, 2045 Hempstead Turnpike, East Meadow, N.Y. (Jan. '51)

## CHANGES IN ADDRESS

*Changes received between November 5 and December 5, 1951*

**Brenden, J. H.**, Gilbert Associates, 412 Washington St., Reading, Pa. (Jan. '48)

**Cecil, Lawrence K.**, Route 6, Box 535, Tucson, Ariz. (Jan. '28) *PR*

**Doyle, William H.**, Dist. San. Engr., State Board of Health, Box 270, Wisconsin Rapids, Wis. (Apr. '42)

**Gilman, Richard R., III**, 410 S. Catalina Ave., Pasadena 5, Calif. (Jan. '51) *PR*

**Harris, W. L.**, Chemist, Filtration Plant, 1430 Monroe, N.W., Grand Rapids 5, Mich. (July '40) *Fuller Award '47*. *P*

**Hendrix, Thomas L.**, 6216 Dustin Dr., Richmond, Va. (Apr. '40) *PR*

**Kavanagh, John F.**, Comptroller, Indiana Gas & Electric Co., 1630 N. Meridian St., Indianapolis 2, Ind. (Oct. '51) *M*

# INTRODUCING...

THE NEW WALLACE & TIERNAN  
FLUORIDATOR

*Series A-635*

**design features**

- Either Volumetric or Loss-of-Weight Control
- Loss-of-Weight Recording (optional)
- Dust-tight Construction
- Special Two-directional Feed Screw
- Large Dissolving Chamber
- Modern Streamlined Appearance
- Wide Feed Range



**S**pecial requirements of Fluoridation — primarily, extreme accuracy and dependability — were considered foremost in the design of W&T's new Series A-635 Fluoridator. A selection of models and a wide feed range make this feeder suitable for the application of sodium fluoride or sodium silicofluoride in most communities.

The basic feeder is volumetric with manual control, featuring the new two-directional feed screw for increased accuracy. Built-in scales can be supplied for periodic checking of the weight of chemical in the hopper.

The gravimetric, loss-of-weight, model is controlled from a unique scale beam housed in a dust-tight compartment. Registers indicate the rate of feed and the weight of chemical in the hopper at all times. Loss-of-weight recording is available with the gravimetric feeder to provide a permanent record of fluoridation.



## Condensation

If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.*—*Bulletin of Hygiene (Great Britain)*; *C.A.*—*Chemical Abstracts*; *Corr.*—*Corrosion*; *I.M.*—*Institute of Metals (Great Britain)*; *P.H.E.A.*—*Public Health Engineering Abstracts*; *S.I.W.*—*Sewage and Industrial Wastes*; *W.P.A.*—*Water Pollution Abstracts (Great Britain)*.

### DAM CONSTRUCTION AND MAINTENANCE

**Maximum Flood Discharge and Reservoir Spillways.** ANON. Wtr. & Wtr. Eng. (Br.), 55:277 ('51). Aimé Coutagne states: "Flood formulas will never be anything but probability formulas, more or less applicable only to specific cases and certain regions." Detg. capac. of water dischg. for dam is problem with no general soln. To supply missing or insufficient local data, general considerations are: [1] using certain formulas of probability giving intrinsic variations of annual or daily flood dischg. as:

$$Q_{\max} = Q_0(1 + K \log T)$$

proposed in '14 by Fuller; [2] using empirical formulas expressing max. dischg. as function of topographical characteristics of basin, as:

$$Q = AS^n;$$

[3] using certain rainfall-river-flow correlations between largest river flows and rainfalls producing them. Coutagne reports  $K$  to vary from 0.500 to 0.835 for Danube, Rhine, Columbia, Rhone, Mississippi, Seine, Merrimack, and Tamise. For Germany, max. floods were practically all covered by formula:

$$Q = 24.12S^{0.316}.$$

For Rhone, Garonne, Loire, and Rhine, he obtained from:

$$Q = 20\sqrt{S} \text{ to } 40\sqrt{S}.$$

**Key:** In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947.

In basin of Haute Garonne, max. is:

$$Q = 200S^{0.4}.$$

Duffaut warns against purely math. formulas. States "all floods are possible. They only differ in their probability." Gibrat states frequency  $R_q$  of observations for discharge less than or equal to given discharge.

$$q = \frac{1}{\sqrt{\pi}} \int_{-\infty}^z e^{-z^2} dz$$

where:

$$z = a \log (q - q_0) + b$$

and  $a$ ,  $q_0$ , and  $b$  are constants. In Gumbel's theory, if  $R_q$  and  $q$  are as above, probability that no  $N$  flows will be greater than  $q$  is  $S = R^N$ , and most probable value  $q_m$  of largest value of dischgs. leads to:

$$R(q_m) = 1 - \frac{1}{N}.$$

New generalization of Fuller's formula is obtained for  $N = 365$ . Hunter and Wilmot state "The heaviest 24-hr rainfall ever recorded was associated with the Norwich storm of Aug. 26, 1912 . . . it occurred over an area possessing a normal annual rainfall of approx. 25 in. . . . apparent preference of exceptional storms for dists. of normally low or moderate rainfall may merely reflect the relative scarcity of records in the more mountainous regions." They consider use of probability paper. Pardé warns against use of math. probability methods. Points to inquiries from river-bank residents, reading of chronicles, and water

(Continued on page 42)



## He services a lot more meters since we got Ford Coppersetters



It is not an exaggerated claim to say that outside meter service men work much faster when meter settings are equipped with Ford Coppersetters. As a matter of record, many utilities report it takes about half the time to change a meter when the Coppersetter is used. It keeps a permanently aligned, rigid setting that permits easy, trouble-free meter changes. Send for the complete Ford catalog that shows these and many other Ford water service aids.

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Wabash, Indiana



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CAST IRON WATER MAINS  
EVER LAID IN 25 REPRESENTATIVE  
CITIES ARE STILL IN  
SERVICE.

Based on the findings of a  
survey conducted by leading  
engineering firms.



# CAST IRON PIPE

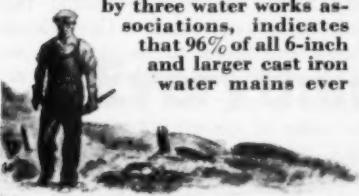
# DISTINGUISHED CLUB...

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The Cast Iron Pipe Century Club is probably the most unusual club in the world. Membership is limited to municipal, or privately-owned, water and gas supply systems having cast iron mains in service for a century or more.

Although the Club is formally constituted, there are no dues, no regular meetings, and no obligations other than to inform the Recording Secretary if and when the qualifying water or gas main is taken out of service, or, sold for re-use.

In spite of the unique requirement for membership, the Club roster grows, year by year. And why not, when a survey sponsored by three water works associations, indicates that 96% of all 6-inch and larger cast iron water mains ever



laid in 25 representative cities are still in service. And when answers to a questionnaire, mailed to gas officials in 43 large cities, show that *original* cast iron mains are still in service in 29 of the cities.

If your records show a cast iron main in service, laid a century or more ago, the Club invites you to send for a handsome framed Certificate of Honorary Membership. Address Thomas F. Wolfe, Recording Secretary, Cast Iron Pipe Century Club, Peoples Gas Building, Chicago 3, Illinois.

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DEPARTMENT OF WATER AND WATER SUPPLY  
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Baltimore, Maryland  
CONSOLIDATED GAS ELECTRIC LIGHT AND POWER CO.  
Baltimore, Maryland  
PUBLIC WORKS DEPT., WATER DIVISION  
Boston, Massachusetts  
BOSTON CONSOLIDATED GAS CO.  
Boston, Massachusetts  
BOARD OF WATER COMMISSIONERS  
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FALL RIVER GAS WORKS COMPANY  
Fall River, Massachusetts  
CITY OF FREDERICK WATER DEPT.  
Frederick, Maryland  
GAS DEPARTMENT  
City of Frederickburg, Virginia  
PUBLIC SERVICE COMMISSION  
City of Halifax, N. S., Public Water Supply  
THE HARTFORD GAS COMPANY  
Hartford, Connecticut  
BUREAU OF WATER  
Lancaster, Pennsylvania  
LOUISVILLE GAS & ELECTRIC CO.  
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CITY OF LYNCHBURG WATER DEPARTMENT  
Lynchburg, Virginia  
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YORK WATER COMPANY  
York, Pennsylvania  
WATER DEPARTMENT  
City of Zanesville, Ohio

\* 8 new members in 1951

## SERVES FOR CENTURIES

(Continued from page 38)

marks. Following methods may be used: [1] . . . take suitable coef. of flow and probable time of rise and fall may be detd., [2] use of unit hydrographs, distr. graphs, rain records and flow coef., [3] calcn. of rate of rainfall and adopting adequate ratio between max. river flow and rainfall rate. Several flood-routing procedures presented. All designed to solve basic eq. of inflow minus outflow storage. Hathaway states a step-by-step computation procedure is ordinarily followed. Gherardelli gives graphical method of integration of:

$$q_a - q_e = \frac{dV}{dt}$$

where  $q_a$ , inflow, is function of  $t$ ,  $q_e$ , outflow, is known function of water level in reservoir and, through head-disch. diagram, also of  $V$ ,  $t$  is time, and  $V$  is storage capac. Normally:

$$q_e = aV^n$$

where  $a$  is constant depending on shape and length of spillway, and  $n$  may be assumed as  $\frac{1}{2}$  for free-disch. spillway. Rydell states considerations governing selection of type and location of dam, spillway, and outlet works form closely interrelated problem. Factors may be: [1] for concrete dam, outlet and spillway can usually be constructed integral with dam; for embankment type dam, these structures must be separately constructed; [2] excluding spillway and outlet considerations and assuming reasonably favorable conditions, cost of earth, gravel, or rock-fill dam in U.S. is usually much lower per unit length than cost of equiv. concrete dam; [3] spillways and outlet works, when constructed as separate structures for earth or rock-fill dam, are relatively costly; [4] operating and maint. characteristics favor spillway and outlet structures integral with concrete dam. Controlled outlets with gates or valves for outflow regulation

are necessary where conservation or multipurpose use of storage is desired. Vertical lift gates dependent on rolling rather than sliding friction are superior to slide gates. Radial, or Tainter, gates represent advance in cost reduction of large-capacity outlet control. For high-head earth dams in which large dischgs. are released through very large conduits or tunnels, economies in design favor large, vertical-lift gates rather than slide gates. Disadvantages of Tainter gate are occurrence of hydraulic disturbances in gate chamber when conduit begins to flow full and more difficult sealing problem. Williamson considers round crest, siphon, and trumpet shaft spillways. First type is based on form of lower nappe of jet over sharp crested weir at max. height of spill. Greater height and broader weir suggested so that, for large spill height downstream, face may come out beyond normal face line of gravity dam. Grzywienski shows conditions to be satisfied as: [1] overfall cross section should not become greater than section of dam for sake of design economy; [2] at max. overfall height, no subpressures should arise; [3] greatest possible hydraulic eff. must be attained. Starting of siphonic action on siphonic spillways, as described by Williamson, depends on creation of vacuum by gradual exhaustion of air from passage by water which falls over crest. On rising, water becomes entangled with air so that on passing out it takes some air. In model test under ordinary atmospheric pressure, it will fail to give indication by its operation of troubles which may arise in full-size siphon from too great vacuum. Depth of trumpet to be adopted in trumpet-shaft spillway related to ultimate veloc. produced when system is flowing full. Detrimental feature of trumpet spillway is curtain of water falling at high speed, breaking

(Continued on page 44)

# The right combination

Layne offers you the right combination of unmatched experience plus modern equipment for installing well water supply units of any size—and for any purpose. Layne has made more water supply installations than any other firm in the entire world, and this valuable experience places Layne in a position to unquestionably do every job exactly right. Once the installations have been made, a complete record of everything is kept; strata formation, sand porosity, casing details, sand screen length, diameter and metal used, all pump information including bearings, shafting, impellers and operating characteristics. With such information, Layne is always in a position to give quick and most economical service for adjustments or repairs if and when needed.



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The logo for Layne Water Supply Wells & Pumps. It features the word "Layne" in a large, stylized, cursive script font. To the left of "Layne" are three small black dots. To the right is a decorative flourish consisting of a vertical line with a curved flourish at the top. To the right of the flourish is the text "LAYNE & BOWLER, INC." in a bold, sans-serif font. Below that is "General Offices, Memphis 8, Tenn." in a smaller, regular sans-serif font. To the right of the text is a decorative flourish consisting of a vertical line with a curved flourish at the bottom. Below the main text are two rows of black dots: a top row with five dots and a bottom row with six dots, creating a horizontal line of 11 dots.

(Continued from page 42)

away from wall to join water flowing down on outside, thereby trapping much air and causing violent disturbance with pockets of subnormal pressure. Govinda Rao describes volatile siphon which consists of dome with funnel placed underneath leaving annular space all around, with vertical pipe taken down funnel to pass dischgs. through dam. When water in reservoir rises above top water level it spills over circumference of lip of funnel, skirts along volutes, and, at throat, falls into barrel forming water seal turning with spiral motion. Difference in pressure equal to only 1.5 ft head of water between inside and outside of water seal is sufficient to start siphonic action.—H. E. Babbitt.

**The Haweswater Reservoir.** G. E. TAYLOR. J. Inst. Wtr. Engrs., 5:355 ('51). Haweswater lends itself to development by stages. In '29 start was made on first installment, to include Haweswater Res. and an aqueduct with one line of pipes to Heaton Park Res. in Manchester. Haweswater is most easterly and highest of lakes in English lake dist. Natural drainage area is 7,970 acres. Constr. of dam will increase storage capacity to 18,660 mil gal (Imp.). Avg. annual rainfall varied from 102.5 in. at southwestern end of watershed to 63.0 in. at northernmost gage. Gross yield estd. to be 35.7 mgd (Imp.). Out of the 80 mgd (Imp.), for complete Haweswater scheme, 9 mgd must be allowed for compensation water. In '29 Burns Bank Village was constructed on site immediately downstream from dam, for 200 workers and their dependents. An access road was constructed 5½ mi. long, 12 ft wide except at passing places, where it is 16 ft. Another 5-mi. road was constructed in '29-'31. Dam is massive buttress type with following advantages: [1] positive limitation of uplift pressure, [2] access for inspection, [3] reduction of

temp. rise of concrete because of nearness of all points to surface, [4] economy of concrete from more eff. disposition of bulk. Max. height is 120 ft. Uplift was assumed to be one-half static head at upstream face, decreasing to tail water level at inside periphery of head. Buttress unit limited to 35 ft, with buttress width of 6 ft. Design saves 37% more concrete than normal gravity dam. Normal safety factor against sliding obtained by sloping water face steeply, to introduce vertical force component. Dam is 1,540 ft long and on rock foundation. In excavation, 43,000 cu yd rock and 36,200 cu yd overburden removed. Rock excavation confined as much as possible to area occupied by buttress units. Natural rock being between them left undisturbed. Diversion channel constructed on southern bank of river, 35 ft wide and 5 ft deep. During constr., two buttress blocks kept lower than others to provide outlet for excess flood waters. Flooding over them occurred several times. Concrete proportions for bulk of work were 1:3.13:3.77. Water-cement ratio was approx. 0.65. Joints between blocks were made watertight by bldg. bent copper strips 0.1 in. thick, extending 5 in. into adjacent blocks. Inlet to aqueduct 2½ mi upstream of dam. Shaft sunk 65 ft below natural ground level and extends upward 42 ft to provide main operating platform 5 ft above top water line. Mardale Tunnel forms first section of aqueduct to Manchester—5 mi long. Is horse-shoe section 7 ft 6 in. high and 7 ft 1 in. wide with gradient of 1:3,000. Reservoir was put into service in Oct. '41. Cost of dam was £476,948; of aqueduct, £544,689; and of entire project, £1,290,264.—H. E. Babbitt.

**Reservoir Site Investigations and Economics.** P. B. MITCHELL. J. Inst. Wtr. Engrs. (Br.), 5:445 ('51). Formulas proposed to determine

(Continued on page 46)



### **ONE MAN REPAIRS — 5 TO 15 MINUTES**

In the **SKINNER-SEAL** SPLIT COUPLING CLAMP, gasket is SEALED at break by Brass Band; at top where compression rings intermesh, by Monel Metal Band.

Insures against recurrence of trouble by introducing a degree of flexibility in the line. Each clamp tests to 800 pounds line pressure. Sizes 2"-24" inclusive. Be prepared — order today.

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**SPLIT COUPLING CLAMP**



**GREENBERG**  
**Independently Valved HYDRANTS**

for non-freezing climates

Western water works engineers and fire chiefs were the first to approve Greenberg California-type fire hydrants. Now, after exhaustive tests, Underwriters' Laboratories, Inc. has confirmed your judgment.

Greenberg No. 74 and 76 hydrants are equipped with independent valves of a new type which open quickly and easily, allowing full flow with minimum resistance. They close tightly without water hammer. A major improvement over the old "cork in bottle" type valve!



Other innovations such as you would expect of the people who evolved the California-type hydrant 75 years ago are shown in the free booklet "Hydrants by Greenberg." May we send you a copy?

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 Washington, D. C.

(Continued from page 44)

depth-storage relationship in reservoirs with min. amt. of survey work. Lapworth's formula, corresponding closely to Sutherland's, is:

$$S = Ch^m$$

where  $S$  is capac. of reservoir,  $C$  is a coef.,  $m$  an exponent, and  $h$  is depth of reservoir. Values of  $m$  are: for lake, 1.0-1.5; flood plain and foothill, 1.5-2.5; hill, 2.5-3.5; and gorge, 3.5-4.5. When plotted on log paper, coef.  $C$  may be checked by taking capac. from straight line for height  $h$ , of 100 ft, when log  $C$  equals log  $S_{100}$  minus  $2m$ . Within economic range of dam height, errors in capac. small. Larger errors occur at lowest values of  $h$ , where storage is too small to be of practical use. Approx. cost of earth dam is given by:

$$C_E = \frac{aLH^2}{7.5} + \frac{bLH}{3} + \frac{2cLD}{9} + 1,900H + 20,000$$

where  $C_E$  equals total cost earth dam,  $H$  is mean height of dam from ground level to 6 ft above top water level,  $L$  is length of dam at top,  $D$  is mean depth of cutoff trench,  $a$  is total cost per cu yd of forming embankment,  $b$  is cost per cu yd of puddle core wall, and  $c$  is total cost per cu yd of cutoff trench. Taking  $a$  to be 0.75,  $b$  to be 2, and  $c$  to be 6.75, formula becomes:

$$C_E = \frac{LH^2}{10} + \frac{2LH}{3} + \frac{3LD}{2} + 1,900H + 20,000$$

Approx. cost of the concrete gravity dam is:

$$C_c = \frac{xLH^2}{72} + \frac{xLw^2}{40} + \frac{yLD_1H}{36} + \frac{2zLD_2}{9} + 15,000$$

where  $C_c$  is total cost of concrete dam,  $H$  is mean height of dam from broad foundation level to 6 ft above top water level,  $L$  is length of dam at top,

(Continued on page 48)

## INSTALLING STEEL WATER MAIN NEAR NATION'S CAPITAL



Because of its convenient 40-ft lengths, Bethlehem Water Pipe is easy to string in the field.

To keep pace with the continuing development of the area north of Washington, D. C., the Washington Suburban Sanitary Commission has installed a new steel water main extending from Rocky Gorge Pumping Station in Prince Georges County, Md., to Wheaton, in Montgomery County, Md. The line consists of 62,400 ft of Bethlehem Tar-Enamelled Water Pipe, in sizes varying from 31 in. to 43 in.

Here is pipe so durable and dependable, so economical, that more and more water-works engineers are giving it first call for water-line service. Bethlehem Tar-Enamelled Water Pipe is virtually leak-proof. It is so resilient that it effectively resists the effects of soil movement after installation. What's more, it is highly resistant to incrustation and corrosion because it is generously coated, inside and out, with a uniformly smooth layer of coal-tar enamel.

Bethlehem Tar-Enamelled Water Pipe is produced in 40-ft lengths, and comes in all practical diameters, starting with a minimum diameter of 22 in. i.d.



Heavy coating of coal-tar enamel keeps Bethlehem Water Pipe in prime condition, year after year. Right: Up, up and over the hill! This junior-size mountain proved a formidable obstacle, but not for long.



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**BETHLEHEM Tar-Enamelled  
WATER PIPE**



These photographs were taken on a 26,000-ft section of the line for which Ligon and Ligon, Baltimore, were the contractors.

(Continued from page 46)

$w$  is width of road or footpath at top,  $D_1$  is mean depth of broad foundation below ground level,  $D_2$  is mean depth of cutoff trench below broad foundation level,  $x$  is cost per cu yd of concrete,  $y$  is cost per cu yd of excavation to broad foundation, and  $z$  is total cost per cu yd of cutoff trench. Taking  $x$  to be 4.5,  $y$  to be 0.3, and  $z$  to be 4.5, formula becomes:

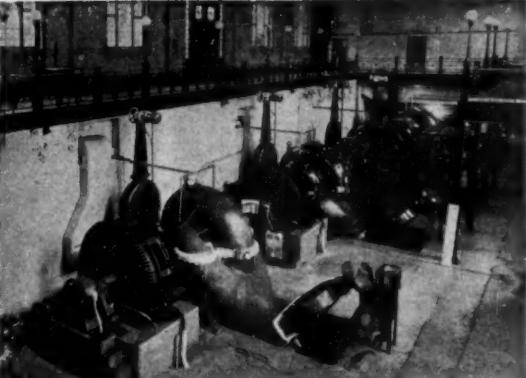
$$C_s = \frac{LH^2}{16} + \frac{Lw^2}{10} + \frac{LD_1 H}{120} + LD_2 + £15,000.$$

Formulas do not include: contingencies; engr's. fees; resident engr. and staff; land and easements; legal and local charges; diversion of railways, roads and other public utilities; acquisition and demolition of buildings; and provisions for alternative housing,

clearing reservoir site, spreading lime, fencing, access roads and bridges, excavation of soft material unsuitable as foundation and replacement with selected materials, cementing below cutoff trench, and camp accommodation or transport of men to site if isolated. Characteristics of any reservoir site may be represented by four curves showing relationship between: [1] height of dam and storage, [2] storage and yield, [3] height of dam and cost, and [4] cost and yield. Curve [1] is obtained from  $S = Ch^m$ ; Curve [2], by using Lapworth chart; Curve [3], from formula for cost of concrete dam; and Curve [4], from other three curves. From Curve [4], cost of development for any required gross yield may be found. In past, sites compared by quoting cost per mil gal stored. Better idea of relative cost

(Continued on page 50)

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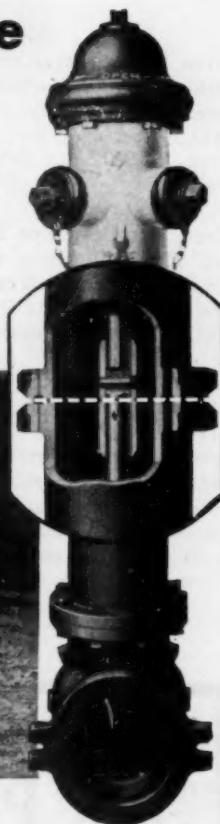
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• **THE KENNEDY SAFETOP** is the only hydrant with the threaded breaking ring that gives positive connection and rigid alignment of the two standpipe sections. Extensive tests and actual service reports show that the Kennedy *Safetop* can stand as tough a blow as the conventional hydrant without damage. But under a smashing impact, it always breaks cleanly at the breaking ring, without damage to working parts.



**SHEARED OFF** by a heavy road-scraping machine at 1:26, the Kennedy Safetop breaks evenly at the ground level.

Photos taken at N. Y. State Section meeting, A.W.W.A., April 1949.



**WITH ONLY** an inexpensive Safetop Repair Kit and a few common tools, one man can permanently repair the Kennedy Safetop.



**NO NEED FOR DIGGING** because breakage is all above ground . . . no flooding because compression-type valve closes with water pressure.



**IN JUST 11 MINUTES** the Kennedy Safetop is back in service . . . working as smoothly and efficiently as if nothing had happened.



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THE **KENNEDY**  
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VALVES • PIPE FITTINGS • FIRE HYDRANTS

(Continued from page 48)

given by comparing cost per mgd of yield. Costs of concrete gravity dams given in table vary from 10,000 to £113,000 per mgd, and, of earth dams, from 51,000 to £320,000.—H. E. Babbitt.

**Description of Some Swedish Earth and Rock-Fill Dams with Concrete Core Walls and Measurements of the Movements and Pressure in the Filling Material and the Core Walls.**  
 G. WESTERBERG; G. PIRA; & J. HAGRUP. Wtr. & Wtr. Eng. (Br.), 55: 316 ('51). At many power plants of State Power Board (Sweden), it was economical to construct dams with rock filling using rock excavated from tunnels and power station sites. Effort made to counterbalance masses in dam with excavated material. At power plant sites, supply of clay or other im-

pervious material usually scant. Type of dam use characterized by vertical impervious central section enclosed on each side by supporting filling of earth or rock. Impervious part consists of thin wall of strongly reinforced concrete in front of which comparatively thin layer of clay or other impervious earth is placed. This type dam offers advantages in climatic conditions during constr. Fine-grained material contg. some water placed during short summer, permitting rock filling throughout whole year. Torpshammar Dam, with max. height of 22 m and length of 480 m, showed vertical settling of approx. 4 cm on upstream side and 2 cm on downstream side. Horizontal movement of concrete core's crest approx. 3 cm for right-hand part resting on moraine and approx. 1 cm for lefthand part resting

(Continued on page 52)

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**HOT PATCH**  
 FOR THE  
**COLD WAR**

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 Of Our Nearest  
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You'd be surprised at how little it costs to modernize an old water filtration plant. After all, some high initial costs included expensive buildings and filter tanks, which are almost always still usable. New interior parts such as strainer systems, air wash systems, filter beds and agitators are comparatively inexpensive. They will give you high flow, low cost water again. Call us in to see how.

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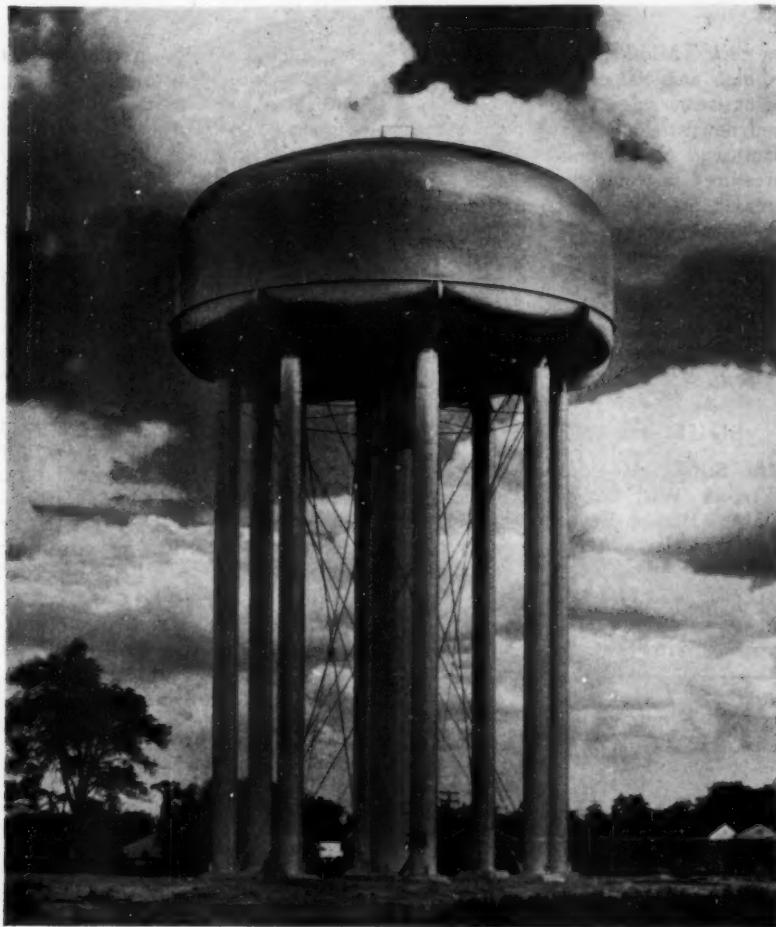


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### *Birmingham Adds Second Radial-Cone Tank*

The City of Birmingham, Mich., has installed the second 500,000-gal. Horton Radial-Cone tank, shown above, in its water distribution system to provide gravity water pressure in the northeast section of the City. The first 500,000-gal. radial-cone tank was built in 1943, and is also in the northeast section of the City. Write our nearest office for information or estimating figures on elevated tanks. State capacity, height to bottom and location.

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HAVANA**

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LOS ANGELES  
WASHINGTON**

(Continued from page 50)

on rock. Midskogsforsen Dam is 28 m high and 400 m long. Settlement of upstream side of dam crest 180 cm and downstream side 60 cm. When dam was placed under water load, pressure instruments indicated increased pressure very nearly proportional to raising of water level. Large stones in earth mass take over increased load on settling of surrounding earth and produce uneven distribution of pressure in earth mass. Max. deflection of core at top 0.5 m.—H. E. Babbitt.

### SOURCES OF SUPPLY

**The Silting of Reservoirs.** ANON. Wtr. & Wtr. Eng. (Br.), 55:140 ('51). Hamed Bey Suleiman stated that: [1] clay and silt are fairly constant throughout vertical, variation

being almost entirely in coarser part of sand portion of suspended solids in Aswan Res., mean concn. at half depth bore constant ratio to mean concn. in water passing whole cross section of river. Hoon found that: [1] coarse and medium silt concns. vary along vertical depth of river and increase from surface downwards, [2] avg. concn. points for coarse and medium silts usually near 0.55 and 0.6 depth. That for coarse silt at relatively lower depths, [3] the 2 subgrades of fine silt do not show marked variation from surface downwards, [4] variation in dischg. seems to affect silt concn. at all points along depth, being low for smaller dischg. and high for larger. Maddock and Borland state, "Unmeasured bedload is usually expressed as proportion of total load on stream or as proportion of measured suspended

(Continued on page 54)

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(Continued from page 52)

load. Data have shown that the bed load may be as much as three times suspended load." Fox states, "Following scouring (and transporting) veloc. may be:

Materials	Veloc. of Stream—fps
Fine clay and mud	0.25
Fine sand and silt	0.50
Coarse sand (peas)	1.0
Fine gravel (beans)	2.0
Coarse gravel (1 in)	3.0
Pebbles (1½ in)	4.0
Heavy shingles (3 in)	5.0 "

Joshi says, "It is only by taking into consideration relative spgr that apparent anomaly of depth of erosion of natural soils and rock not agreeing with depth of silt received through floods and deposited in tanks per unit

area of catchment can be solved." Lane mentions effect of density currents in reservoir. "Such currents may flow scores of miles down bottom of reservoir underneath clear water without mixing appreciably with it." Pick states, "Studies which have been made indicate definite possibility that density currents may carry substantial portion of total sediment load of Missouri R. downstream along bottom of large, main-stem reservoirs to dams." Duquennois states "Most economical and effective way of reducing sedimentation consists in utilization of underflow for outflow through dischg. valves of silt which usually gathers on bottom of reservoirs." Raynaud reports comparison between free surface flows and math. expression for these flows is given. Drouhin remarks, "It is evident that process of

(Continued on page 56)

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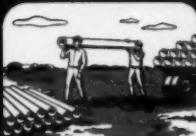


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"Century" Pipe is moderate in price. And, though it is exceptionally strong, it is also light in weight and easy to handle: installation is quick, easy, and at low cost.

Add to these the durability of "Century" Pipe, its absolute freedom from tuberculation, its high resistance to soil corrosion and immunity to electrolysis, and you'll quickly see why: *Before you buy or specify any pipe for water mains, it will pay you to investigate "Century" Asbestos-Cement Pressure Pipe.*

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(Continued from page 54)

silting in reservoir depends on rate of fall of different particles . . . which may vary within proportion of 1:100,000, according to grain size." Rao and Raghavachari gives three stages in process of sedimentation: "[1] in earlier years, after constr. of dam, lake will be formed with surface level at diversion level and will stretch back to where river bed meets with diversion level, [2] silt in suspension will be carried by rivers to this point where heavy silt deposition will occur, [3] rolled sand will confine itself to old deep river bed. After series of years, cross section of bottom of reservoirs at right angles to river course will become almost level plain." Drouhin summarizes some of figs. given for silting. Expression in cu m of silt deposited per year per sq km of catchment area. Figs. in Los Angeles

watershed, vols. involved vary from 400 to 9,600 cu m with peaks reaching 3 or 4 times as much. Only scant information exists on subject of silting of reservoirs. No general method known whereby life of reservoir can be estd.—H. E. Babbitt.

**The Digley Reservoir Scheme of the Huddersfield Corporation Waterworks.** ANON. Wtr. & Wtr. Eng. (Br.), 55:159 ('51). Constr. of 700-mil gal (Imp.) impounding reservoir, filter station, 6.86 mi of pipeline, booster pumping station, and service reservoir will add 3 mgd (Imp.) to supply. On night of Feb. 4, 1852, violent storm broke over watershed. Drawoff from reservoir was inadequate. Water topped low part of embankment, causing complete destruction. Disaster caused death of 81 per-

(Continued on page 58)

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(Continued from page 56)

sons and growth of industry in Holme Valley was stayed for many years. Reservoir now under constr. will have capac. of 700 mil gal (Imp.). Filters will be of pressure type with capac. of 3 mgd (Imp.). Pipeline from reservoir to service reservoir is 24-in. diam. concrete-lined, c-i pipe. Booster plant with capac. of 0.5 mgd (Imp.) will be used only during very dry weather to assist Deerhill Res., which is now very much overdrawn. Service reservoir at Newsome will have capac. of 2.5 mil gal (Imp.). Total estd. cost of scheme is £1,185,277.—  
*H. E. Babbitt*

**The Planting of Trees on Reservoir Banks.** H. F. CRONIN, J. Inst. Wtr. Engrs. (Br.), 5:548 ('51). In absence of experience, it is sometimes difficult to refute specious arguments or persuade a parliamentary commit-

tee that practice is fraught with danger to banks. Lambeth Waterworks Co. obtained permission to construct storage reservoir at Molesey. During passage of bill, portion of bank planted with trees to satisfy local resident. Bank was planted with mixture of sycamore, wild cherry, willow, laburnum, false acacia, lime, and others. Trees flourished. Settlement was noticed 39 yr. later on portion of bank planted with trees. Trial holes showed many roots penetrated puddle wall. Greatest distance from puddle wall of any tree whose roots penetrated was approx. 25 ft, but some roots traveled 50 ft before entering. All trees within 30 ft of top of bank were cut down, and all willows regardless of position. Every large root growing toward puddle from all trees felled uncovered and removed.—*H. E. Babbitt*



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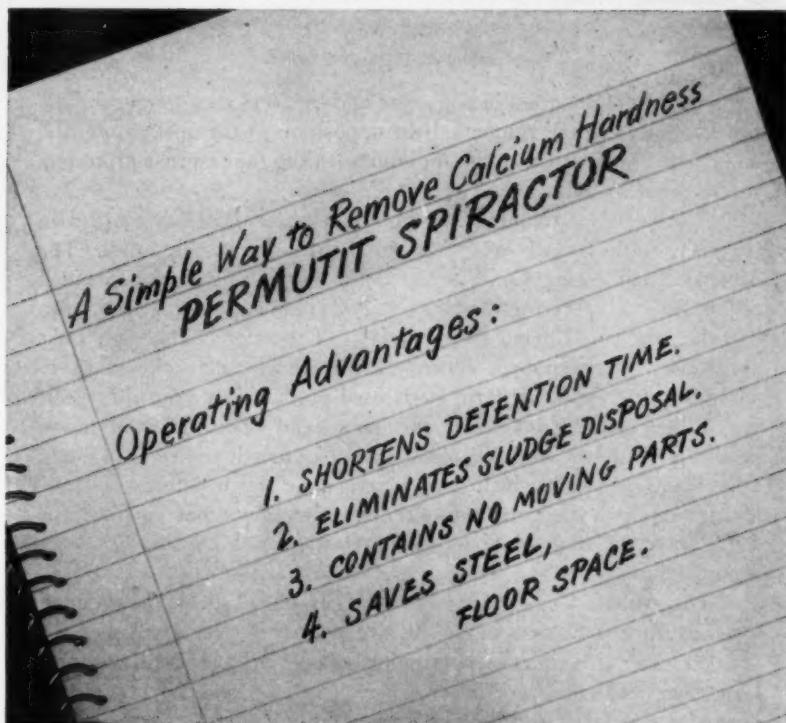
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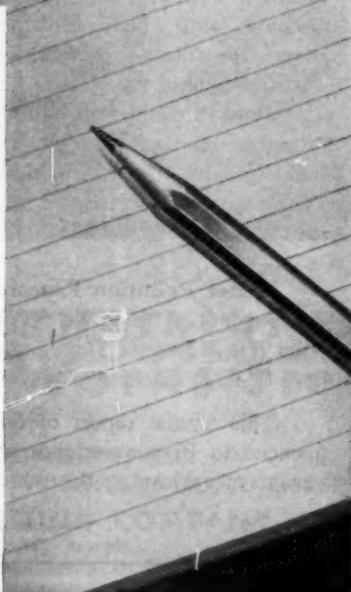


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WATER CONDITIONING HEADQUARTERS FOR OVER 38 YEARS

## *The Reading Meter*

*(Continued from page 22)*

see how the combination of engineers and business men fought for the necessary legislation, combatted the opposition in the upstream cities, and carried the battle through the courts—all to the end that protective works could be built.

A group of consultants of the highest engineering ability was drawn together, with Daniel W. Mead of Wisconsin at the head. The Morgan Engineering Co. with Arthur Morgan as its chief, planned the works. Underlying the project as completed was the basic idea of *retarding*, not *storing* flood waters. The earth dams with their permanent waterways cut across the Miami channel. Above them along the river lie fertile farm lands used productively year after year.

When heavy rains come, the dams hold back the flood flows, permitting only a calculated quantity to pass down the river. Flood flows have occurred which would have done much damage if there had not been flood protection, although none since has equalled the 1913 flood. The flood flows were retarded and Dayton has been spared.

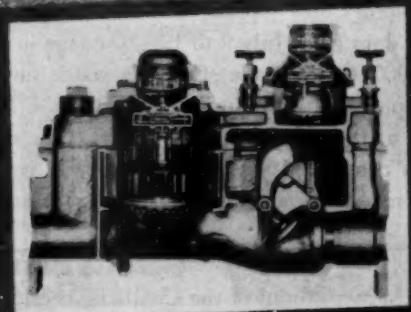
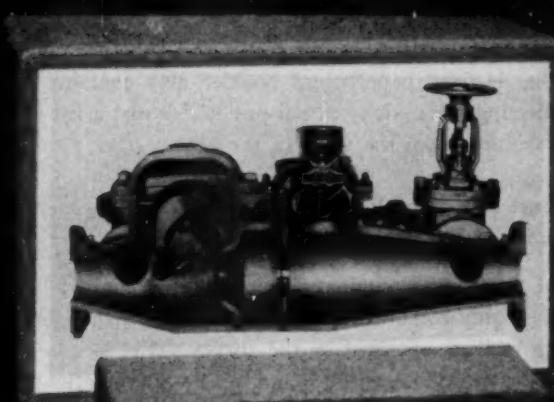
The Miami Conservancy works bear close study in planning for the future in Kansas, along the streams that concentrated the fury of flood water at Kansas City, bringing disaster to Manhattan, Topeka, Lawrence, and dozens of other towns. Retarding dams permit the normal use of farm land for crop production, in contrast to the multi-purpose dams which permanently inundate thousands of acres and induce the siltation that destroys the flood control and power production value of the works.

Morgan could well have emphasized, much more strongly than he did in his book, the long-range effects of the various methods of flood control. That task, objectively done by one as competent as he, needs to be done by someone, and done before too many more mistakes have been made.

**Water Pollution Research—1950.** *Water Pollution Research Board, Dept. of Scientific & Industrial Research, London (1951) 40¢ from His Majesty's Stationery Office, York House, Kingsway, London, W.C. 2, England.*

This annual report of pollution research conducted by official agencies in Britain includes reports on the treatment of sewage by various means, and on the treatment of industrial wastes resulting from

*(Continued on page 62)*



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### *The Reading Meter*

*(Continued from page 60)*

the manufacture of paper, the discharge of rockets, and the draining of coal mines. The 44-page paperbound booklet also contains a report on factors affecting the toxicity of poisons to fish and a list of 1950 publications resulting from the work of the board.

**Kansas-Missouri Floods of July 1951.** *Circular 151, Geological Survey, Washington 25, D.C. (1951) free.*

The Geological Survey's preliminary report on the highly destructive floods of last July contain extensive data on the stages and discharges at gaging stations operated by the survey. The floods—the worst in the area since 1844—were brought on by two months of higher than normal stream flow topped by more than 10 in. of rain which fell in the four days from July 9 to 12. Damage in the region is estimated at \$900,000,000; and the effects on water supply plants were severe (see September 1951 JOURNAL, p. 681). The report contains, in addition to the tabulations and charts, only a brief descriptive text, and is considered preliminary. It was released primarily to aid in reconstruction and future planning.

**P. H. McGauhey**, formerly head of the Civil Engineering Dept., Virginia Polytechnic Inst., has joined the University of California faculty, and is in charge of sanitary engineering research projects there. Among the projects are studies of the travel of pollution underground, the recharge of ground water by spreading of treated sewage plant effluent, the removal of boron from water, and the disposal of radioactive wastes.

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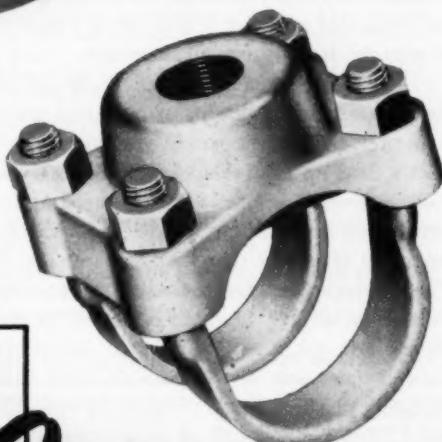
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## Section Meeting Reports

**Virginia Section:** Following the usual custom of alternating the annual meeting of the Virginia Section between Richmond and Roanoke, 223 members and guests returned to Hotel Roanoke for a three-day meeting starting Wednesday, November 7. In previous years the meeting has occupied two days; however, everyone was convinced the three-day meeting was desirable in many ways. It is expected that a three-day meeting will be planned for subsequent meetings.

The large attendance at the technical sessions was most gratifying and the response in discussing papers was exceptional. R. D. Wright, chairman, presided at the opening session and welcomed the members and guests. "Let's Seal up Our Abandoned Wells" was the title of the first paper by Paul Schweitzer, president of the Layne-Atlantic Co., Norfolk. After mentioning several fatal accidents caused by abandoned open wells, the author also observed that many abandoned flowing wells in some areas of Virginia were depleting ground water needed by municipalities and industries. Garland S. Sydnor, president of the Sydnor Pump and Well Co., Richmond, discussed "Municipal and Industrial Wells," and W. Calvin Falwell, president of the Falwell Well Drilling Co., Lynchburg, spoke on "Drilling of Hard Rock Wells in Central Virginia." Linn Enslow then offered "Some Thoughts on Improving Water Supply Service and Raising the Status of the Industry."

The final topic of the afternoon session was an open discussion on fluoridation led by H. E. Lordley, assistant director of the Richmond Dept. of Public Utilities. This lively subject was discussed from all angles, including cost of installations, availability of chemicals, testing requirements, handling of the chemical, desirable points of application, and types of feed equipment under various conditions; and, if time permitted, the discussion would still be going on.

The technical session was resumed Thursday morning when X. D. Murden, superintendent of the Water Dept. at Portsmouth, presided over a panel discussion on civil defense. The panel included L. H. Arnold,

(Continued on page 66)



American Concrete Cylinder Pipe for Higher Pressure Service

American Centrifugal Pressure Pipe for Low and Moderate Operating Heads

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You know that reinforced concrete pressure pipe gives you the strength of steel and the permanence of concrete . . . with reductions in initial cost, lower installation costs, sustained capacity, and trouble-free service. Four classes of reinforced concrete pressure pipe are available to meet varying requirements. So why not use the proper combination of these classes of pipe, where pressure ranges differ, to meet the needs not only of high pressure service but the needs of intermediate and low pressure service as well?

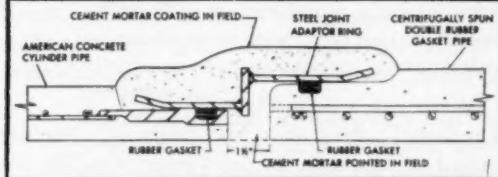
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So . . . if you find that the pressure ranges in your line are going to differ widely, give us the opportunity to show you how the combination of different classes of American reinforced concrete pressure pipe can save you money.

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A simple adaptor ring provides the transition between the spigot ends of two different classes of pipe.

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*(Continued from page 64)*

president of the Arnold Co., Richmond, who discussed "Communications," W. R. Odor, sales manager of Lynchburg Foundry Co., Lynchburg, who spoke on "Inventories," and J. H. Wyse, coordinator of the state Office of Civilian Defense, Richmond, who spoke on "Mutual Aid and Mobile Support Groups."

Later, a resolution was adopted by the membership which observed that a critical need exists for adequate equipment, materials and appurtenances for the operation and protection of public water supplies in event of a disaster, and asked that the federal Civil Defense Administration be petitioned and urged to include in its budget sufficient funds for purchase and maintenance of such emergency equipment. A.W.W.A. Secretary H. E. Jordan discussed "Current Problems of the Water Works Industry."

In the afternoon session, C. H. Rutledge, of the Public Relations Dept., E. I. DuPont de Nemours & Co., Wilmington, Del., spoke on "Human Engineering." A paper entitled "Atomic Energy Programs in Relation to Water Supply and Purification" was delivered by Arthur Gorman, sanitary engineer with the Div. of Engineering, Atomic Energy Commission, Washington, D.C. W. R. LaDue, superintendent and chief engineer of the Bureau of Water and Sewerage, Akron, Ohio, was unable to be present to deliver his paper entitled "Continuing Maintenance—Or Else!" but it was read by C. E. Moore, engineer of construction for the Roanoke Water Dept. Marsden C. Smith, chief water engineer of the Dept. of Public Utilities, Richmond, presented a paper on "Pneumatically Applied Cement Mortar in Water Works Structures."

The final session of the meeting was held Friday morning. Two movies, "Pipeline to the Clouds" and "Trenton Cleans its Water Mains," were presented and were followed by a symposium on "New Water Works in Virginia." "Staunton's New Plant" was described by H. R. Knight, engineer, Myron Sturgeon Engineers, Norfolk. "Norton's New Plant" was discussed by R. K. McCord, town manager of Norton, and W. Martin Johnson, partner, Wiley & Wilson Engineers, Lynchburg, described "Pulaski's New Plant." F. O. Biehn, partner, R. Stuart Royer Associates, Richmond, concluded with "Wytheville's New Plant."

Entertainment features included a floor show and dance on Thursday night. Ladies were entertained at luncheon at the Tinker Tea Tavern, Hollins College, after which they were taken on a sightseeing tour to Mill Mountain and then back to the Pine Room for card games. Club room entertainment was furnished at appropriate hours by the representatives of the manufacturers attending the meeting.

Following the annual banquet "The Old Dominion Citation" awards were presented the following members: R. C. Bardwell, C. D. Blackwelder, J. D. Capron, E. F. Dugger, L. A. Geupel, H. A. Johnson, Richard Messer,

*(Continued on page 68)*

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This meter is built with maximum differentials of 114" or 64" of water to measure over ranges of 13 to 1 and 10 to 1 respectively. Standard design includes indicating, recording and totalizing features but, if desired, it may be furnished with various combinations of these elements.

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# SIMPLEX

VALVE AND METER COMPANY

(Continued from page 66)

C. E. Moore, M. C. Smith, C. W. Smedberg and H. W. Snidow. This award is presented to honor those members who have been engaged in the collection, conditioning and distribution of pure water in Virginia, for their long and faithful service to their respective communities, the Commonwealth of Virginia and industry.

It was announced that as Fuller Award recipient the committee had selected H. W. Snidow, Regional Engineer, Bureau of Sanitary Engineering, State Health Department, Richmond, Va., with the following citation:

"For his devoted and modest service to the Commonwealth of Virginia in the field of Water Supply and Sanitation; and for his untiring efforts in promoting the organization of the Section."

W. H. SHEWBRIDGE  
*Secretary-Treasurer*

**Wisconsin Section:** The Wisconsin Section held its 30th annual meeting in Milwaukee at the Hotel Pfister on September 25-27, 1951. A total registration of 305 established a new attendance record, the previous one being 301 in 1949.

The Fuller Award Committee selected Albert E. Hintz, Superintendent of Water Works at Oshkosh, to receive the award for "his 30-odd years of service to the Oshkosh Water Works and, during the same time, his keen interest and untiring efforts in the promotion of the activities of the Wisconsin Section of the American Water Works Association."

Tuesday morning, September 25, was devoted to registration. Preliminaries at the opening session in the afternoon, presided over by Chairman Frank K. Quimby, included official greetings and presentation of the proverbial key to the city by an official thereof, opening remarks by the chairman and the report of the secretary-treasurer. Leon A. Smith, who has served the Wisconsin Section in the latter capacity for 24 years, was for the first time in his many years of service unable to attend the annual meeting, being confined to his home because of illness.

The meeting was divided into four sessions—Surface Water, Ground Water, Preparedness and General, and half a day was devoted to each. Each session included two prepared papers and a panel discussion, a format which has been followed with considerable success for the past several years. A half hour program of movies, not necessarily technical, preceded each session except the first. This practice has been found to be successful in attracting a gratifying attendance for the start of the technical program.

The Surface Water Session on Tuesday afternoon was presided over by Norton A. Thomas, assistant superintendent of filtration at Milwaukee. John G. Frisch, Madison, presented the first paper on "Controlled or Uncontrolled Fluoridation—A High or Low Dental Decay Rate for Your

(Continued on page 70)

## ARMCO STEEL PIPE

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**6" AND 36"**

Wide range of diameters plus a choice of wall thicknesses from 9/64- to 1/2-inch permits you to select the right water pipe for your job. Long lengths up to 50 feet help keep down installation costs. Write for complete details. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 1042 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation.



**ARMCO STEEL PIPE**

MEETS  
A. W. W. A.  
SPECIFICATIONS

*(Continued from page 68)*

Community," a subject which provoked an interesting and informative discussion.

Dr. Frisch stated that properly controlled fluoridation can eliminate two-thirds of the dental caries in the population. Wisconsin experience indicates that 1.2 ppm. of fluorides in the water supply produce the maximum resistance to dental decay. Few natural waters contain the correct amount. However, results at Sheboygan prove that the artificial addition of fluorides is just as effective. Decay is easily detected in fluoridated teeth without X-ray, and the addition of fluorides to water produces no ill effects on the health of the individual. Wisconsin leads in fluoridation with 97 communities, which include 90 per cent of the State's urban population, providing fluoridated water or installing equipment for it.

The second paper in the Surface Water Session was on "Stream Pollution Control in Wisconsin," presented by T. F. Wiśniewski, director of the Wisconsin Stream Pollution Committee. Considerable progress has been made in this field since this committee was created by the state legislature in 1927. The committee's program is aimed at providing adequate sewage treatment facilities and advancing industrial water pollution control programs, particularly in the pulp and paper industry, the canning industry and the dairy industry.

The industries are giving the state committee excellent cooperation in reducing waste discharges into streams and rivers. The pulp and paper industry is accomplishing this through the installation of fiber recovery equipment, in-plant control practices aimed at cutting down chemical losses, production of fodder yeast from sulphite liquors, evaporation and burning of sulphite liquor and the installation of reaeration facilities. The canners' associations have developed chemical precipitation plants, waste disposal lagoons, and most recently, the spray irrigation method to dispose of cannery wastes. The dairy industry has initiated a program to reduce the annual loss of approximately 300 million pounds of milk in the wastes produced by Wisconsin's 2,250 dairy plants. Also, some 5 billion pounds of whey produced by the cheese industry are sold to condenseries which manufacture various byproducts.

The stream pollution control program also protects aquatic and wild life which contribute so much to the attractiveness and recreational value of numerous resort and park areas in the state.

The panel discussing the above papers, as well as other surface water subjects, included the two speakers and Bruno J. Hartman, consulting engineer, Sheboygan; A. J. Marx, engineer, Menasha Electric and Water Utilities; Norton A. Thomas; and Harvey E. Wirth, sanitary engineer, State Board of Health.

*(Continued on page 72)*



## DOUBLE SQUARE BOTTOM

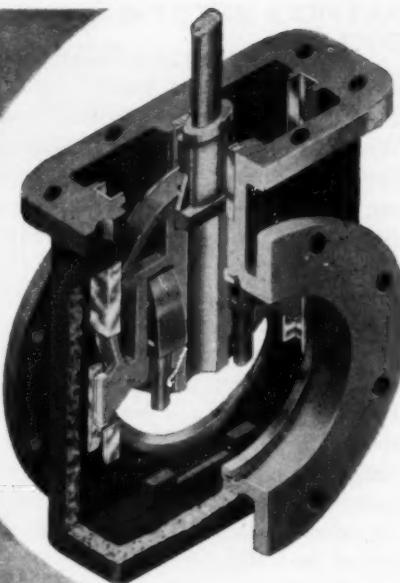
## GATE VALVES

When it is desired to install a gate valve for throttling purposes, or in a vertical pipe line, M & H double square bottom valves have many important advantages.

When valve is opened, each of the three shoes on both discs immediately contact the feathered edge of the tracks. These three contacts result in the disc being eased away instantly from the seat. The shoes then ride the tracks squarely and firmly for the full travel of the disc. In closing, discs ride the tracks down to a point exactly opposite the valve seat. At that point, the discs are clear and free to seat by action of the two spreaders, each functioning independently of the other.

M & H double square bottom valve prevents the down stream gate from tilting into the down stream port opening and by chatter or vibration damaging the seat and gate rings. These valves can be installed with either disc on the down stream side.

Available in classes A, B, and C, sizes 3" and larger. Where needed, can be supplied with rollers; or roller, tracks and scrapers. For complete information, write or wire M & H Valve and Fittings Company, Anniston, Alabama.



**M & H PRODUCT**

*Everywhere*

(Continued from page 70)

Thomas M. McGuire, manager, Plymouth Utilities Commission, presided over the Ground Water Session on Wednesday morning, September 26. The first paper, entitled "Methods Used in Ground Water Studies in Wisconsin," was offered by William J. Drescher, district engineer, U.S. Geological Survey, Madison. It described the methods practiced and the use made of municipal water levels and pumpage data. Four factors were discussed: [1] the recharge of ground water, [2] ground water geology, [3] discharge of ground water and [4] water levels and artesian pressures. The various methods of collecting and analyzing data, particularly as they applied to the above four factors, were described.

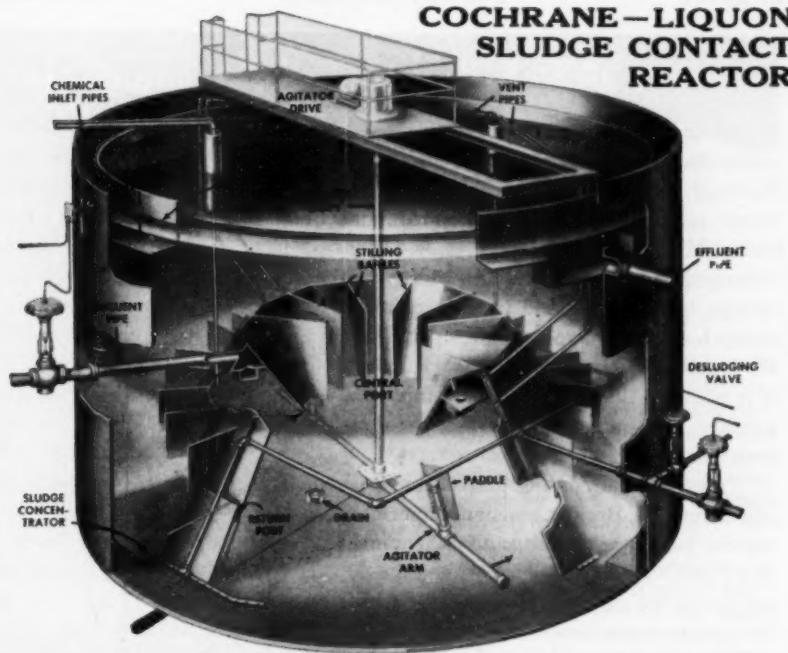
The second paper was a discussion of "Experiences in the Development of Ground Water Supplies in the Wausau Area." It was presented by Howard Potter of the Jerry Donohue Engineering Co., Sheboygan, who showed on a map the location of various test holes drilled in and near Wausau to locate a suitable supply of water. He discussed the quality of water pumped at each hole, the reasons for selecting the final site, and the plans for operating the well to reduce the possibility of increasing the iron content of the water.

Participating in the panel discussion were the above two speakers and E. F. Bean, state geologist; A. Becher, water department, Wausau; Edward F. Kipp, superintendent, Marshfield; William Leistikow, superintendent, Wausau; and Thomas M. McGuire, manager, Plymouth. The experience of Wausau, as outlined in Mr. Potter's paper, was discussed at length. Mr. Potter and Mr. Muegge, state sanitary engineer, considered the prospect of controlling the iron content of water by reducing the pumping rate. It was agreed that this might be only a temporary measure. Mr. Bean spoke briefly on the various methods of locating water-bearing formations, stating that improvements were being made in these methods.

The Wednesday noon luncheon, at which 110 persons were present, was privileged to hear A.W.W.A. Vice-President Charles H. Capen who brought greetings to the Wisconsin Section from the national association. He complimented the section on the program, the conduct of the meetings and the excellent attendance at the sessions. Mr. Capen spoke briefly on the literature available to the membership from its Association, particularly "Defense News," "Willing Water" and booklets such as "What Price Water." This literature carries a wealth of essential information and guidance in public relations that can be used to excellent advantage.

The Preparedness Session on Wednesday afternoon was presided over by Richard E. Cannard, manager, Manitowoc Utilities. The first paper, by Arthur E. Gorman, sanitary engineer, Atomic Energy Commission, Washington, D.C., presented some aspects of the problem of radioactivity and water supply (*see November JOURNAL, p. 865*).

(Continued on page 74)



## EMBODIES ALL 8 BASIC DESIGN REQUIREMENTS of the Sludge Contact Process

1. Two zones are provided; mixing zone below, clarifying zone above, separated by inclined baffles.
2. Raw water is uniformly distributed into mixing zone. Clarified water is collected evenly by a circular flume at the top periphery (plus radial flumes on larger diameter units).
3. Chemicals are introduced at the point where raw water enters, mixing chemicals, water and slurry simultaneously.
4. Variable speed agitator insures uniform, constantly agitated slurry mixture.
5. Slurry passes from mixing zone through ports in the baffles into the clarifying zone. A large central port plus a small peripheral port avoids conflict of rising water with the returning sludge from the clarifying to the mixing zone.
6. Slurry spreads out across full area of tank above crest of baffles, water rising slowly to separate from sludge.
7. Slurry spills over edge of baffles into sludge concentrator, settling and thickening and being withdrawn at intervals through diaphragm-operated valve.
8. Duration of desludging is controlled by timer. Automatic back-flushing of sludge collector pipe is also provided.

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# COCHRANE

PROCESS AND EQUIPMENT IN WASTEWATER PROCESS & INDUSTRIAL WATER CONDITIONING



*(Continued from page 72)*

The second paper in the Preparedness Session, "Priorities and Procurement of Materials," by Charles H. Capen, discussed shortages of materials and operating supplies and construction controls which the water works industry must recognize and cope with. Mr. Capen discussed the National Production Authority's CMP Regulation 5 covering maintenance, repair and operating supplies, and minor capital additions under the Controlled Materials Plan. A.W.W.A. Defense News, No. 5, September 1951, summarizes very completely the rules, regulations and procedures governing ratings, bookkeeping and records, controlled and other than controlled materials for maintenance, repair, operation and minor capital additions under \$750, called MRO, and materials for major construction in excess of \$750. It is essential that the industry complies with every regulation to obtain the supplies and materials necessary for maintenance, operation and construction.

The panel discussing preparedness problems included the two speakers plus Elmer W. Becker, assistant superintendent of water works, Milwaukee; and O. J. Muegge, state sanitary engineer. After assembly of the discussion panel, O. J. Muegge explained the working of the Wisconsin inventory and exchange of material system. Although there was some response to the questionnaire sent out, the system could work to better advantage if all utilities would cooperate. E. W. Becker of the Milwaukee Water Dept. gave an illustrated report of an assumed atomic attack on the Milwaukee area. He explained the Milwaukee organization and how it would function if an atomic attack were experienced.

A general discussion was maintained on the effects of atomic bombing on surface water supplies, the necessity of knowing, and being able to use, any emergency supplies; as well as the necessity for water utility men to train for and understand the new era if they are to perform their job under emergency conditions.

Albert E. Hintz, superintendent of water works, Oshkosh, presided at the General Session on Thursday morning. Ervin C. Weickert of the Water Construction Division, Milwaukee, presented the first paper on "Investigating the Condition of Underground Structures in the Milwaukee Water Works Distribution System." For the past five years, an engineer has been assigned to make daily inspections of existing mains and services exposed at locations where new construction or repair work is in progress. Approximately 500 reports have been made on ground and soil conditions, pipe corrosion, electrical tests, condition of mains and services and main failures. The information so obtained aids in determining the condition of mains and services and the repairs and replacements necessary prior to street paving work. In addition, however, essential data are being obtained on materials, methods of construction and ground conditions conducive to long service life, and for the rehabilitation and valuation of the system.

*(Continued on page 76)*

# Designs from engineers' notebooks

## **Inclined Sluice Gate in EVERDUR**

In this design for 12 sluice gates 36 in. x 36 in. to operate at a 20-degree angle from the vertical, Everdur® (ANACONDA Copper-Silicon Alloys) was chosen for all the structural components, including gates, guides, stems and anchor bolts. While Everdur's immunity to rust, resistance to corrosion and high structural strength are essential to any installation of this nature, they are of special significance here in view of the higher inherent friction component.

These 12 Everdur gates are a part of an installation of 57 for The Overpeck Valley Joint Sewage Works, Bergen County, N. J., Bergen County Sewer Authority. They were designed and built by The Coldwell-Wilcox Div. of Krajewski-Pesant Mfg. Corp. to plans and specifications of Bogert-Childs Engineering Associates of New York.

Everdur has long demonstrated its ideal properties for waterworks, sewage installations, and disposal of industrial wastes. These strong, lightweight, easily welded alloys are widely used for such wrought assemblies as screens, float chambers, weirs, troughs, manhole steps and similar equipment. For full details write to The American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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*(Continued from page 74)*

The second paper, "Essential Equipment for the Operation and Maintenance of Water Works Facilities," was presented by E. Miles Griffith, engineer, Racine Water Dept. Among the equipment recommended were test benches for meters of all sizes, trucks with special bodies for meter work and for tapping, electronic pipe locators, valve operating devices, air compressors, thawing equipment, portable generators, portable power drive units and a hydro-crane. It is very important, also, that the engineering division have sectional maps showing all mains, valves, hydrants and services. In the discussion that followed, the policy of renting equipment arose; majority opinion favored owning to renting.

A committee report was presented by Albert E. Hintz on the "Proposed Revision of the Statutes to Clarify the Authority of Utility Commissions." Only one of four bills presented by the committee to the state legislature passed in the last session. It was recommended that the committee be prepared to present its bills well in advance of the legislative session so that they would not be lost in the mass of bills presented for consideration, as they were in the last session.

A panel consisting of the two speakers and Richard E. Cannard, manager, Manitowoc Utilities; H. O. Londo, superintendent, Green Bay; Joseph Lustig, acting City Manager, Janesville; and Arthur Rynders, engineer, Milwaukee Water Works, participated in the discussions.

Social events of the convention included an informal party on Tuesday evening at the Blatz Brewing Co. plant, a ladies' luncheon at the Milwaukee Athletic Club on Wednesday afternoon, and a banquet and floor show at the Hotel Pfister on Wednesday evening.

LEON A. SMITH  
*Secretary-Treasurer*

**Cuban Section:** The annual meeting of the Cuban Section took place at the headquarters of the Cuban Society of Engineers, Havana, on November 20-December 1. At no time in the history of the section has such interest been aroused by any gathering. The meeting was given extensive coverage in the newspapers, and front page headlines were devoted to the forum on the water supply for the city of Havana. This forum had been sponsored by the section for the previous two months.

The greatest proof of the importance the section has acquired is the fact that the central government, as well as the municipalities, consults it on all matters concerning water and sewage, and, for the first time in the history of Cuba, the technical men are making themselves heard, and are trying to bring to the people of Cuba the true picture of water supply problems without the intervention of politics in any form.

The opening meeting was attended by Mayor Nicolas Castellanos of Havana, who addressed the meeting and promised to abide by the recom-

*(Continued on page 78)*



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### FEATURES

#### LARGE HOPPER CAPACITY

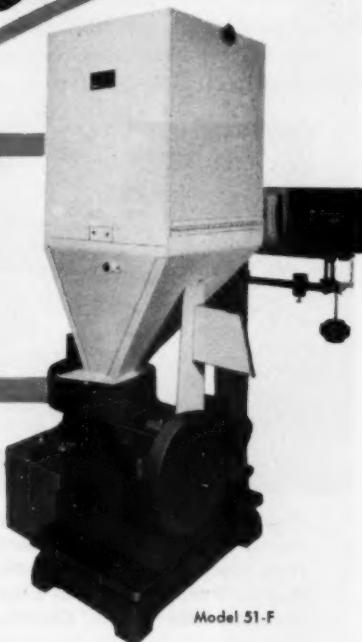
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**OMEGA**  
The Last Word in Feeders



(Continued from page 76)

mendations that the section would make for the water supply of greater Havana.

The first paper was a discussion by George Broderman, one of Cuba's outstanding geologists, of the "Hydrological Behavior of Cuban Geological Formations." Jesús Valdés Roig next presented his calculations on the Gilbert Arch Dam, and his paper, together with the data presented, was very amply discussed. There are several schools of thought on the design of dams, and Valdés Roig presented a new and unique theory that, although not accepted by all, nevertheless has to be taken into consideration.

Next, Abel Fernández presented a valuable contribution on "Stream Flow and Level Measurement at Aguada del Cura and Vento," together



Food and drink provide a pleasant interlude as the Cuban Section meets. Discernible at the rear are (left to right): Ernesto E. Trelles (half obscured), Fuller Awardee Abel Fernández, Miss María Choca, Manuel Puente, Chairman Luis Radelat, Secretary Laurence Daniel, Director Luis Nuñez, Chairman-Elect Gustavo Bequer, and Luis de Sena.

with a petrographic and water analysis. This paper was illustrated with a number of slides, and was also discussed at length.

Sergio Martinez contributed a paper on the "Per Capita Costs of Cuban Water Works," showing the sorry picture in all its details. Under present conditions, the costs of operation are such that the revenue received does not cover the costs, and unless something is done soon, bankruptcy will result. This is the real result of demagoguery, which has always told the public that the water companies are fattening on the gains gotten from the downtrodden people. No politician ever tells the people the truth: that even costs are not covered, let alone profit.

Ignacio García Bengochea, one of the section's youngest and most enthusiastic members, presented a "Theoretical and Experimental Study

(Continued on page 80)



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There's no better corrosion insurance than Reilly pipe line enamels! Reilly pipe line enamels, made from coal tar, protect pipe line surfaces against corrosion, erosion and abrasion wherever the lines are laid. These enamels withstand extreme temperature conditions . . . their hard but flexible surfaces are highly resistant to wear . . . are ideally suited for use in wet or moist soils.



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(Continued from page 78)

of Specific Yield of the Southern Basin of Havana Province," and showed that there was little reason to fear the drying up of Havana's water supply in the near future. His work also elicited great discussion, as the problem of salt water encroachment is ever present, especially on the Caribbean coast, which is low and marshy.

The last paper presented was a discussion of the characteristics and method of selection of deep well pumps, by the section Director, Luis Nuñez. He presented a most extraordinary picture; and one that showed that the majority of deep well pumps are incorrectly selected. This is due in great part to the fact that manufacturers, in their eagerness to promote sales, do not give reliable data, and when the pumps are selected for their lower cost, they do not always live up to the guarantees.

As for the social side of the section meeting, it probably was the best ever, although the section's esteemed friends from Florida and the national Association were missed. The cocktail party at Bacardí Bar was highly successful, and the stories this year were better than ever. It is always refreshing to forget water for a while and go over to Bacardí Rum for variety.

The announcement made by the Fuller Award Committee, one of the high spots of the meeting, indicated that Abel Fernández had been nominated to receive the section's award for his outstanding work in water supply.

On Saturday, a fine excursion was made to all of the works now under construction, and the city of Havana supplied transportation and entertained the section with a fine buffet at the Havana Water Works.

The final event was the party at the Havana Yacht Club, at which Luis Radelat handed over the reins to Chairman-Elect Gustavo Bequer.

Membership in the section is growing, and it is hoped that a number of new members will be attracted in the next year. The monthly meetings at the Colony Club and the Forum will be continued, and it is predicted that 1952 will be a banner year in every respect.

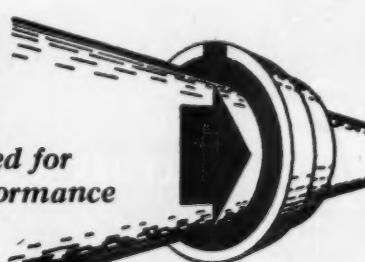
LAURENCE H. DANIEL  
Secretary-Treasurer

(Continued on page 82)

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Portion of main pump room, Park Cities Water Treatment Project. Shown are 13 of the 22 Economy Pumps installed on this project.

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It pays to specify Economy Pumps for water supply. For detailed information and illustrated catalogs write today to Dept. AG-1.



View in University Park Booster Station, part of the Park Cities project. These Economy Pumps boost the pressure going to the overhead storage tank, located 5 miles from the treatment plant.



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*(Continued from page 80)*

**Iowa Section:** The Iowa Section held its annual meeting in Dubuque, Iowa, on October 25-27, 1951, with chairman Mark Driftmier presiding.

During the afternoon session on Thursday, Dewey W. Johnson of the Cast Iron Pipe Research Assn. showed a group of interesting pictures and explained how cast-iron mechanical-joint pipe is made. W. E. Jones, assistant to the chief engineer of the Iowa State Highway Commission, explained the law governing the construction of paved highways inside the city limits. R. D. McGill of the H. C. Nutting Co., Cincinnati, Ohio, discussed valve replacement and records. Tom C. Thorpe of the Thorpe Well Co. spoke about wells and water supplies.

During the same afternoon, in the Purification Division, "Tastes and Odors in Water" was discussed by a panel composed of F. M. Middleton of the U.S. Public Health Service, Marcus P. Powell of the University of Iowa, M. E. Rew of Council Bluffs, J. A. Sampson of the Iowa State Dept. of Health, J. F. Erdei of Omaha, Neb., and George Lee of Ottumwa, all chemists. Then a lively discussion took place on the subject of "Corrosion Control of Softened Water," led by Paul Laux, superintendent of water works, Columbus, Ohio. Arnold Cherry of Cedar Rapids, J. R. Maloney of Des Moines, and Ray Hoops of Marshalltown served on the panel.

On Friday morning O. J. Muegge, Wisconsin state sanitary engineer, told about the application of fluorides to water supplies. Leon Smith, superintendent of water works at Madison, Wis., submitted a paper—which Leo Louis read—on the subject "Salaries of Water Works Employees." Some of the facts disclosed by this report were amazing.

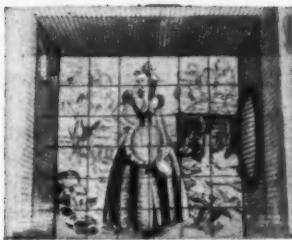
On Friday afternoon the question box was opened by P. F. Morgan of the University of Iowa, and the panel of experts, consisting of C. W. Varner of the Varner Well Drilling Co., J. A. Sampson of the State Public Health Service, R. L. Morris of the State Hygienic Laboratory and G. C. Ahrens of Ottumwa, answered the questions. The question box idea is a very good one, and the hour went by far too soon. Then the group went on an inspection tour of the A. Y. McDonald Co. brass foundry, where it saw how valves and corporation stops are made.

On Saturday morning those who stayed over learned about the use of mobile radio from J. G. Suor of Motorola, Inc. This means of communication apparently has its place in the larger communities. Then chairman Mark Driftmier called a business session to order and heard reports of the auditing, resolutions, legislative and section activities committees. J. J. Hinman Jr. was chosen as the recipient of the George Warren Fuller award.

A total of 180 persons attended the meeting and enjoyed the entertainment which was ably handled by Joe Hail, chairman of the local committee. Everyone seemed to enjoy themselves and the 1951 meeting in Dubuque will certainly be remembered as a successful one.

H. V. PEDERSEN  
*Secretary-Treasurer*

# Increased Supply for Springs Mills...

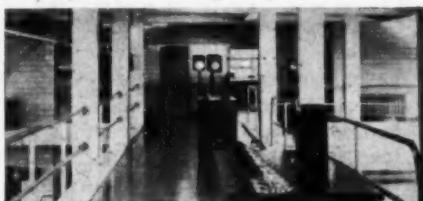


Through the clear well

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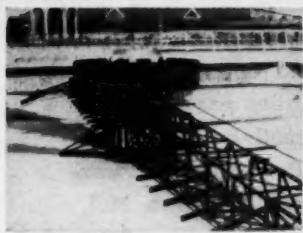
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FOR ALL BURIED AND  
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(Continued from page 20)

far too long and much too often, was watched by far too many lay spectators, and others like myself, was in no way made use of for profitable gain, overflowed in a degree indicative of constant (but periodic) ingress, and so on.

To attribute it to the "supernatural" is, I admit, not much more than a play on words, as the laws behind psychical phenomena are still obscure. That they do exist is unquestioned by those in authority to know—not only is telepathy a fact, for example, but so is a variety of physical phenomena involving energy (demonstrated as early as 1870 by Sir William Crookes *et al.*, to name one example).

Whatever the considered opinion of AWWA or of others who have taken the interest to form one, it will be appreciated. I trust I may have permission to quote some passages from the comments in the JOURNAL.

WILLIAM E. COX JR.  
Resthaven  
Box 936  
Southern Pines, N.C.; Dec. 3, 1951

*Considered opinion being rather difficult now that the barrel has vanished, we can merely observe that water works wonders are more permanent. After all by a strictly natural twist of the hydrologic cycle you almost always keep your reservoirs sort of self-filled.—Ed.*

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**WARREN** Cast Iron Pipe is produced in all sizes from 2" to 84" with all types of joints . . . . fittings in numerous non-standard patterns to meet unusual requirements.

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Simplex Valve & Meter Co.

Wallace & Tiernan Co., Inc.

## Chemists and Engineers:

(See Prof. Services, pp. 25-29)

## Chlorination Equipment:

Builders-Providence, Inc.

Everson Mfg. Corp.

Proportioners, Inc.

Wallace & Tiernan Co., Inc.

## Chlorine Comparators:

Hellige, Inc.

Klett Mfg. Co.

Proportioners, Inc.

Wallace & Tiernan Co., Inc.

## Chlorine, Liquid:

Solvay Sales Div.

Wallace & Tiernan Co., Inc.

## Clamps and Sleeves, Pipe:

R. H. Baker & Co., Inc.

James B. Clow & Sons

Dresser Mfg. Div.

M. Greenberg's Sons

James Jones Co.

Kensselaer Valve Co.

Skinner, M. B., Co.

A. P. Smith Mfg. Co.

Smith-Blair, Inc.

## Clamps, Bell Joint:

Carson-Cadillac Co.

James B. Clow & Sons

Dresser Mfg. Div.

Skinner, M. B., Co.  
Smith-Blair, Inc.

## Clamps, Pipe Repair:

R. H. Baker & Co., Inc.

James B. Clow & Sons

Dresser Mfg. Div.

Skinner, M. B., Co.

Smith-Blair, Inc.

Warren Foundry & Pipe Corp.

## Clarifiers:

American Well Works

Belco Industrial Equipment Div.

Chain Belt Co.

Cochrane Corp.

Dorr Co.

Graver Water Conditioning Co.

Infilco Inc.

Permutit Co.

Walker Process Equipment, Inc.

## Cleaning Water Mains:

Flexible Underground Pipe Cleaning  
Co.

National Water Main Cleaning Co.

## Condensers:

United States Pipe & Foundry Co.

## Contractors, Water Supply:

Boyce Co., Inc.

Layne & Bowler, Inc.

## Controllers, Liquid Level,

### Rate of Flow:

Builders-Providence, Inc.

Infilco Inc.

Simplex Valve & Meter Co.

R. W. Sparling

## Copper Sheets:

American Brass Co.

## Copper Sulfate:

General Chemical Div.

Tennessee Corp.

## Corrosion Control:

Calgon, Inc.

Dearborn Chemical Co.

## Couplings, Flexible:

R. H. Baker & Co., Inc.

DeLaval Steam Turbine Co.

Dresser Mfg. Div.

Philadelphia Gear Works, Inc.

Smith-Blair, Inc.

## Diaphragms, Pump:

Dorr Co.

Morse Bros. Mchly. Co.

Proportioners, Inc.

## Engines, Hydraulic:

Ross Valve Mfg. Co.

## Engineers and Chemists:

(See Prof. Services, pp. 25-29)

## Feedwater Treatment:

Belco Industrial Equipment Div.

Calgon, Inc.

Cochrane Corp.

Dearborn Chemical Co.

Graver Water Conditioning Co.

Hungerford & Terry, Inc.

Infilco Inc.

Permutit Co.

Worthington Pump & Mach. Corp.

## Ferric Sulfate:

Tennessee Corp.

## Filter Materials:

Johns-Manville Corp.

Infilco Inc.

Northern Gravel Co.

Permutit Co.

## Filters, Incl. Feedwater:

Cochrane Corp.

Dorr Co.

Everson Mfg. Corp.

Infilco Inc.

Morse Bros. Mchly. Co.

Permutit Co.

Roberts Filter Mfg. Co.

Ross Valve Mfg. Co.

## Filtration Plant Equipment:

Builders-Providence, Inc.

Chain Belt Co.

Cochrane Corp.

Graver Water Conditioning Co.

Hungerford & Terry, Inc.

Infilco Inc.

Omega Machine Co. (Div., Builders Iron Fdry.)

Permutit Co.

Roberts Filter Mfg. Co.

Stuart Corp.

Welsbach Corp., Ozone Processes

Div.

## Fittings, Copper Pipe:

Dresser Mfg. Div.

M. Greenberg's Sons

Hays Mfg. Co.

James Jones Co.

A. P. Smith Mfg. Co.

## Fittings, Tees, Ells, etc.:

American Cast Iron Pipe Co.

R. H. Baker & Co., Inc.

Carlton Products Corp.

Cast Iron Pipe Research Assn.

James B. Clow & Sons

Dresser Mfg. Div.

James Jones Co.

Kennedy Valve Mfg. Co.

M & H Valve & Fittings Co.

United States Pipe & Foundry Co.

Warren Foundry & Pipe Corp.

R. D. Wood Co.

## Flocculating Equipment:

Chain Belt Co.

Cochrane Corp.

Dorr Co.

Infilco Inc.

Permutit Co.

Stuart Corp.

Walker Process Equipment, Inc.

## Fluoride Chemicals:

American Agricultural Chemical Co.

Blockson Chemical Co.

## Furnaces:

Jos. G. Pollard Co., Inc.

## Furnaces, Joint Compound:

Northrop & Co., Inc.

## Gages, Liquid Level:

Builders-Providence, Inc.

Infilco Inc.

Simplex Valve & Meter Co.

R. W. Sparling

## Gasholders:

Chicago Bridge & Iron Co.

Pittsburgh-Des Moines Steel Co.

## Gaskets, Rubber Packing:

James B. Clow & Sons

Northrop & Co., Inc.

Smith-Blair, Inc.

## Gates, Shear and Sluice:

Armclo Drainage & Metal Products,

Inc.

James B. Clow & Sons



*Reinforce all joints subject to vibration with*

## **CLOW** Mechanical Joint BELL SPLIT SLEEVES

When ponderous trucks roar and rumble by, even our finest highways tremble with vibration . . . and so does the water pipe buried below! That's why it's best to play it safe: don't wait for a break; have the foresight to install Clow Mechanical Joint Bell Split Sleeves as *original equipment* wherever the pipe must pass under highway truck routes or under railroad tracks. Specify them for marshland or under water, too—in fact, everywhere that pipe is not readily accessible in case of emergency. They're easy to install! . . . no lead, no jute, no caulking!

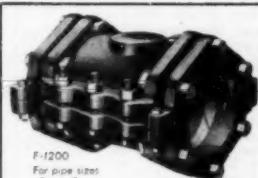
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subsidiaries: Eddy Valve Company, Waterford, N.Y.;  
Iowa Valve Company, Oskaloosa, Iowa.



F-1200  
For pipe sizes  
3" to 16"

Use these F-1200 Clow Mechanical Joint Straight Split Sleeves for permanent repairs to pipe barrels. 12" and smaller sizes will repair lengthwise breaks up to 8 inches; 14" and 16" sizes, up to 17 inches.

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Philadelphia Gear Works, Inc.

**Glass Standards—Colorimetric Analysis Equipment:**  
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Klett Mfg. Co.  
Wallace & Tiernan Co., Inc.

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Hays Mfg. Co.  
James Jones Co.  
A. P. Smith Mfg. Co.

**Hydrants:**

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M. Greenberg's Sons  
James Jones Co.  
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John C. Kupferle Foundry Co.  
Ludlow Valve Mfg. Co.  
M & H Valve & Fittings Co.  
A. P. Smith Mfg. Co.  
Kensselaer Valve Co.  
Ross Valve Mfg. Co.  
R. D. Wood Co.

**Hydrogen Ion Equipment:**

Hellige, Inc.  
Wallace & Tiernan Co., Inc.

**Ion Exchange Materials:**

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Hungerford & Terry, Inc.  
Infilco Inc.  
Permutit Co.  
Roberts Filter Mfg. Co.  
Rohm & Haas Co.  
**Iron Removal Plants:**  
American Well Works  
Belco Industrial Equipment Div.  
Chain Belt Co.  
Cochrane Corp.  
Graver Water Conditioning Co.  
Hungerford & Terry, Inc.  
Infilco Inc.  
Permutit Co.  
Roberts Filter Mfg. Co.  
Walker Process Equipment, Inc.  
Welsbach Corp., Ozone Processes Div.

**Jointing Materials:**

Atlas Mineral Products Co.  
Hydraulic Development Corp.  
Leadite Co., Inc.  
Northrop & Co., Inc.

**Joints, Mechanical, Pipe:**

American Cast Iron Pipe Co.  
R. H. Baker & Co., Inc.  
Carson-Cadillac Co.  
Cast Iron Pipe Research Assn.  
James B. Clow & Sons  
Dresser Mfg. Div.  
United States Pipe & Foundry Co.  
Warren Foundry & Pipe Corp.  
R. D. Wood Co.

**Leak Detectors:**

Jos. G. Pollard Co., Inc.

**Lime Slakers and Feeders:**

Dorr Co.  
Infilco Inc.  
Omega Machine Co. (Div., Builders Iron Fdry.)  
Permutit Co.

**Magnetic Dipping Needles:**

W. S. Darley & Co.

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Builders-Providence, Inc.

**Meter Boxes:**

Art Concrete Works  
Ford Meter Box Co.  
Pittsburgh Equitable Meter Div.

**Meter Couplings and Yokes:**

Badger Meter Mfg. Co.  
R. H. Baker & Co., Inc.

Dresser Mfg. Div.  
Ford Meter Box Co.  
Hays Mfg. Co.  
Hersey Mfg. Co.  
James Jones Co.  
Neptune Meter Co.  
Pittsburgh Equitable Meter Div.  
Smith-Blair, Inc.  
Worthington-Gamon Meter Co.

**Meter Reading and Record Books:**

Badger Meter Mfg. Co.

**Meter Testers:**

Badger Meter Mfg. Co.  
Ford Meter Box Co.  
Hersey Mfg. Co.  
Neptune Meter Co.  
Pittsburgh Equitable Meter Div.

**Meters, Domestic:**

Badger Meter Mfg. Co.  
Buffalo Meter Co.  
Hersey Mfg. Co.  
Neptune Meter Co.  
Pittsburgh Equitable Meter Div.  
Well Machinery & Supply Co.  
Worthington-Gamon Meter Co.

**Meters, Filtration Plant, Pumping Station, Transmission Line:**

Builders-Providence, Inc.  
Infilco Inc.  
Simplex Valve & Meter Co.  
R. W. Sparling

**Meters, Industrial, Commercial:**

Badger Meter Mfg. Co.  
Buffalo Meter Co.  
Builders-Providence, Inc.  
Hersey Mfg. Co.  
Neptune Meter Co.  
Pittsburgh Equitable Meter Div.  
Simplex Valve & Meter Co.  
R. W. Sparling  
Well Machinery & Supply Co.  
Worthington-Gamon Meter Co.

**Mixing Equipment:**

Chain Belt Co.  
Infilco Inc.  
Walker Process Equipment, Inc.

**Ozonation Equipment:**

Welsbach Corp., Ozone Processes Div.

**Pipe, Asbestos-Cement:**

Johns-Manville Corp.  
Keasbey & Mattison Co.

**Pipe, Brass:**

American Brass Co.

**Pipe, Cast Iron (and Fittings):**

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Cast Iron Pipe Research Assn.  
James B. Clow & Sons  
United States Pipe & Foundry Co.  
Warren Foundry & Pipe Corp.  
R. D. Wood Co.

**Pipe, Cement Lined:**

Cast Iron Pipe Research Assn.  
James B. Clow & Sons  
United States Pipe & Foundry Co.  
Warren Foundry & Pipe Corp.  
R. D. Wood Co.

**Pipe Coatings and Linings:**

The Barrett Div.  
Cast Iron Pipe Research Assn.  
Centriline Corp.  
Dearborn Chemical Co.  
Koppers Co., Inc.  
Reilly Tar & Chemical Corp.  
Warren Foundry & Pipe Corp.

**Pipe, Concrete:**

American Pipe & Construction Co.  
Lock Joint Pipe Co.  
Price Bros. Co.

**Pipe, Copper:**  
American Brass Co.

**Pipe Cutting Machines:**  
James B. Clow & Sons  
Jos. G. Pollard Co., Inc.  
A. P. Smith Mfg. Co.

**Pipe Jointing Materials; see Jointing Materials**

**Pipe Locators:**  
W. S. Darley & Co.  
Jos. G. Pollard Co., Inc.

**Pipe, Plastic:**  
Carlton Products Corp.

**Pipe, Steel:**  
Armaco Drainage & Metal Products, Inc.  
Bethlehem Steel Co.

**Pipelines, Submerged:**  
Boyc Co., Inc.

**Plugs, Removable:**  
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Jos. G. Pollard Co., Inc.  
A. P. Smith Mfg. Co.  
Warren Foundry & Pipe Corp.

**Potentiometers:**  
Hellige, Inc.

**Pressure Regulators:**  
Ros Valve Mfg. Co.

**Pumps, Boiler Feed:**  
DeLaval Steam Turbine Co.  
Peerless Pump Div., Food Machinery Corp.

**Pumps, Centrifugal:**  
American Well Works  
DeLaval Steam Turbine Co.  
Economy Pumps, Inc.  
Morse Bros. Mchly. Co.  
Peerless Pump Div., Food Machinery Corp.  
Worthington Pump & Machinery Corp.

**Pumps, Chemical Feed:**  
Infilco Inc.  
Proportioners, Inc.  
Wallace & Tiernan Co., Inc.

**Pumps, Deep Well:**  
American Well Works  
Layne & Bowler, Inc.  
Peerless Pump Div., Food Machinery Corp.

**Pumps, Diaphragm:**  
Dorr Co.  
Morse Bros. Mchly. Co.  
Proportioners, Inc.

**Pumps, Hydrant:**  
W. S. Darley & Co.  
Jos. G. Pollard Co., Inc.

**Pumps, Hydraulic Booster:**  
Ros Valve Mfg. Co.

**Pumps, Sewage:**  
DeLaval Steam Turbine Co.  
Economy Pumps, Inc.  
Peerless Pump Div., Food Machinery Corp.

**Pumps, Sump:**  
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Layne & Bowler, Inc.  
Peerless Pump Div., Food Machinery Corp.

**Pumps, Turbine:**  
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Layne & Bowler, Inc.  
Peerless Pump Div., Food Machinery Corp.

**Rate Analysis:**  
Recording & Statistical Corp.

**Recorders, Gas Density, CO<sub>2</sub>, NH<sub>3</sub>, SO<sub>2</sub>, etc.:**  
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Wallace & Tiernan Co., Inc.



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Unprecedented durability of CARLON plastic pipe assures many years of dependable trouble-free service. It offers outstanding advantages for drinking water transmission, sewage handling, land drainage, irrigation and numerous other applications.

This new pipe is absolutely guaranteed against rot, rust and electrolytic corrosion. It will not accumulate scale or sediment, and is inert to the action of corrosive soils and fluids.

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Specify the Pipe with the Stripe!

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Dearborn Chemical Co.  
Dorr Co.  
Graver Water Conditioning Co.  
Hungerford & Terry, Inc.  
Infilco Inc.  
Permutit Co.  
Roberts Filter Mfg. Co.  
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Worthington Pump & Mach. Corp.

**Softening Chemicals and Compounds:**

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Infilco Inc.  
Permutit Co.  
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**Standpipes, Steel:**

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Proportioners, Inc.

Wallace & Tiernan Co., Inc.

Welsbach Corp., Ozone Processes

Div.

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Chicago Bridge & Iron Co.  
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A. P. Smith Mfg. Co.

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Industrial Chemical Sales Div.  
Infilco Inc.  
Permutit Co.  
Proportioners, Inc.  
Wallace & Tiernan Co., Inc.  
Welsbach Corp., Ozone Processes  
Div.

**Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:**

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**Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):**

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Wallace & Tiernan Co., Inc.

**Turbines, Steam:**

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Worthington Pump & Mach. Corp.

**Turbines, Water:**

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**Valve Boxes:**

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Ford Meter Box Co.  
M & H Valve & Fittings Co.  
Rensselaer Valve Co.  
A. P. Smith Mfg. Co.  
R. D. Wood Co.

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**Valves, Altitude:**

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**Valves, Gate:**

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Kennedy Valve Mfg. Co.

**Ludlow Valve Mfg. Co.**

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Rensselaer Valve Co.  
A. P. Smith Mfg. Co.  
R. D. Wood Co.

**Valves, Hydraulically Operated:**

James B. Clow & Sons  
Golden-Angerson Valve Specialty Co.

Kennedy Valve Mfg. Co.

M & H Valve & Fittings Co.

Philadelphia Gear Works, Inc.

Rensselaer Valve Co.

A. P. Smith Mfg. Co.

R. D. Wood Co.

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Kennedy Valve Mfg. Co.

Ludlow Valve Mfg. Co.

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Rensselaer Valve Co.

A. P. Smith Mfg. Co.

R. D. Wood Co.

**Valves, Regulating:**

Golden-Angerson Valve Specialty Co.

Ross Valve Mfg. Co.

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James B. Clow & Sons

Golden-Angerson Valve Specialty Co.

M. Greenberg's Sons

M & H Valve & Fittings Co.

Rensselaer Valve Co.

A. P. Smith Mfg. Co.

R. D. Wood Co.

**Waterproofing:**

Dearborn Chemical Co.

Inertol Co., Inc.

**Water Softening Plants; see Softeners****Water Supply Contractors:**

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**Water Testing Apparatus:**

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Wallace & Tiernan Co., Inc.

**Water Treatment Plants:**

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Belco Industrial Equipment Div.

Chain Belt Co.

Chicago Bridge & Iron Co.

Dearborn Chemical Co.

Dorr Co.

Everson Mfg. Corp.

Graver Water Conditioning Co.

Hungerford & Terry, Inc.

Infilco Inc.

Permutit Co.

Pittsburgh-Des Moines Steel Co.

Roberts Filter Mfg. Co.

Walker Process Equipment, Inc.

Wallace & Tiernan Co., Inc.

Welsbach Corp., Ozone Processes

Div.

Worthington Pump & Mach. Corp.

**Well Drilling Contractors:**

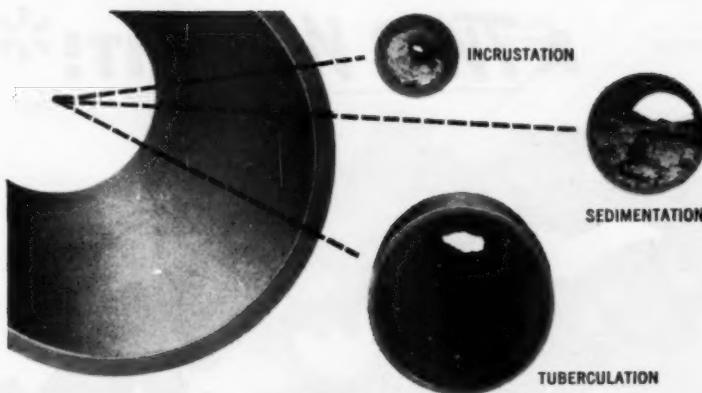
Layne & Bowler, Inc.

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*National knows how to work quickly reducing supplementary labor costs and service interruptions.*

*National knows how to clean the difficult jobs, including hard incrustations, unusual obstructions and pipes of unusually large or small diameter.*

*National knows how to clean long runs with a minimum number of pipe entries.*

*National knows how to avoid trouble, such as can occur from improper provision for drainage of flush water from large mains or from the use of excessive pressures.*

*National knows how to clean so thoroughly that restoration of 95% of the original pipe capacity is guaranteed.*

National Know-How comes from over 40 years of experience cleaning water mains.

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34



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# A TWO WAY HIT!\*



Assembly consists of two single register Pittsburgh-Empire compound meters complete with four Fig. 115 Nordstrom valves and two 8-in. reducing manifolds. The laying length conforms to A. W. W. A. standards for 8-in. compound meters.

**ROCKWELL  
8-INCH MANIFOLD  
COMPOUND  
METER UNIT**

\*This dual unit is

1. **Easier to install and service**
2. **Assures accurate measurement and long life at low cost**

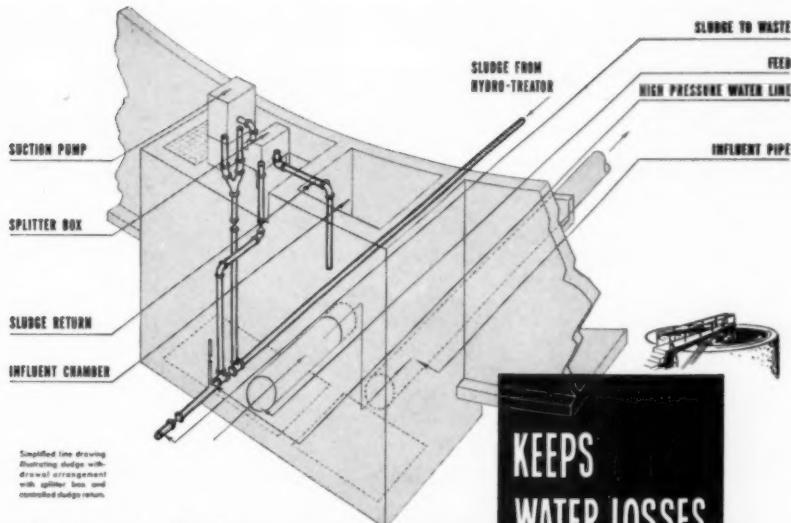
This dual assembly of Pittsburgh-Empire compound meters is easier to handle—the complete unit of meters, valves and piping weighs approximately 100 lb less than a single 8-inch meter. It can be broken down in sections for easy two-man installation. Too, maintenance is simplified since one side of this dual unit can be shut down without service interruption while a new meter or a shop calibrated repaired meter is being installed.

*The initial cost for most installations is less! Write for full details.*



**ROCKWELL MANUFACTURING COMPANY**

PITTSBURGH 8, PA. Atlanta Boston Chicago Columbus  
Houston Kansas City Los Angeles New York Pittsburgh  
San Francisco Seattle Tulsa



*Here's how the Dorco Hydro-Treator*

**KEEPS  
WATER LOSSES  
DOWN...**

Treated water that's lost in waste sludge at the pre-treatment step is just as important—and costly—as every gallon that goes to the filters or mains. The Dorco Hydro-Treator has two exclusive features that cut these losses . . . and at the same time improve the entire operation—whether its softening, color or turbidity removal or a combination of all three.

**FIRST** Thick, dense sludge produced by the squeezing action of the rotating rakes on the Hydro-Treator floor and sludge pocket, is positively removed at final density from the tank with a Dorco VM variable stroke Pump operated by a program time clock.

**SECOND** Pump discharge falls to a splitter box where a regulated amount of sludge is mixed and returned to the tank with the incoming raw water. These factors cut water loss to an absolute minimum. If you'd like more information on the Hydro-Treator—operating results, drawings and photographs—and a complete description with sample specifications; a new 32-page bulletin #9041 has just been printed and will be sent on request. Address your inquiries to The Dorco Company, Barry Place, Stamford, Conn.; or in Canada, to The Dorco Company, 80 Richmond Street, West, Toronto 1. No obligation, of course.

Hydro-Treator is a trademark of The Dorco Company, Reg. U. S. Pat. Off.



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# LEADITE

Trade Mark Registered U. S. Pat. Office

## Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains **MUST BE GOOD,—MUST BE DEPENDABLE,—** and that is just why so many Engineers, Water Works Men and Contractors aim to **PLAY ABSOLUTELY SAFE**, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

*The pioneer self-caulking material for c. i. pipe.  
Tested and used for over 40 years.  
Saves at least 75%*

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